SUPPLY CHAIN QUALITY RISK MANAGEMENT: AN EMPIRICAL STUDY OF ITS DIMENSIONS AND IMPACT ON FIRM PERFORMANCE

YING KEI TSE, BSc, MSc

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The following sections/pages have been excluded at the request of the university:

Page 272 Appendix 5 – Invitation letter (Chinese)

Page 273 Appendix 6 – Endorsement letter (Reply)

Page 274 – Letter of Endorsement

ABSTRACT

The goal of this dissertation is to understand what supply chain quality risk management (SCQRM) is and how SCQRM can help firms improve product quality and firm performance. This dissertation attempts to reveal and understand the SCQRM practices in order to provide new insights in dealing with supply chain quality risk. Thus, this dissertation aims to address three research questions: RQ1) What should SCQRM entail in order to reduce the risk to the quality of products being handled along the supply chain? RQ2) What would a valid measurement scale of SCQRM entail? RQ3) What is the impact of SCQRM on product quality and firm's performance?

In this research, a comprehensive SCQRM framework is proposed. SCQRM is conceptualised as a multidimensional, second-order construct that is represented by a system of four interrelated and complementary dimensions: risk shifting, risk sharing, risk avoidance, and risk remedy. These four SCQRM dimensions are subsequently examined in the conceptual model in relation to performance, and three key approaches are adopted: (a) statistical analysis to validate the measurement instrument of SCQRM; (b) measurement model analysis technique to investigate multi-dimensionality of SCQRM; (c) structural model building technique to examine the relationships between SCQRM dimensions and performance. In such,

quantitative analysis techniques, exploratory factor analysis (EFA), confirmatory factor analysis (CFA) and structural equation modelling (SEM), are adopted to analyse survey data from 289 companies.

Three contributions to knowledge are made in advancing the literature of SCQRM. Firstly, this study reports a 7-stage procedure for developing a reliable and valid measure of SCQRM. Secondly, the measure of SCQRM is found to be a multidimensional construct consisting of four unique dimensions. Thirdly, this study examines the significant positive effect of the complementarity system of SCQRM on product quality and on firm performances. Moreover, the findings imply that a successful SCQRM results from building a complementarity power in risk management resources and routines. The multiple manifestations of the four SCQRM dimensions are all driven by a cohesive, yet unobserved synergy, which also forms one of the competences of the firm. Moreover, the managerial implication suggests that complementary benefits arise from the adoption of a more holistic approach to the management of supply chain quality risk at the firm-level.

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LIST OF ABBREVIATIONS

AVE – Average Variance Extract

CFA – Confirmatory Factor Analysis

EFA – Exploratory Factor Analysis

IPSHK – Institute of Purchasing and Supply Hong Kong

ISM-PRD – The Institute for Supply Management, Pearl River Delta

PRD – Pearl River Delta Region (China)

RM – Risk Management

RSF – Risk Shifting

RSR – Risk Sharing

RAV – Risk Avoidance

RRY – Risk Remedy

SCM – Supply Chain Management

SCR – Supply Chain Risk

SCRM – Supply Chain Risk Management

SCQR –Supply Chain Quality Risk

SCQRM – Supply Chain Quality Risk Management

SME – Small and Medium Sized Enterprise

CHAPTER 1. INTRODUCTION

1.1 BACKGROUND

The recent rise in the number of product recalls reveals that manufacturing firms are particularly vulnerable to lapses in product quality and safety where goods and materials have been sourced globally i.e. quality risk in global supply chain. As shown in Figure 1.1, the number of recall cases in EU countries due to quality and safety problems doubled during the period 2005-2010 (RAPEX 2011). The impact of quality risks involves various industries. In some serious cases, the so called highly reputable companies being famous for excellent quality performance in the past are not immune from the impacts, from major recalls in the car-industry like Toyota (Kumar and Schmiz 2011), to the food industry in China, and even down to simple low technology manufacturing in China as in the toy industry (Tse and Tan 2011).

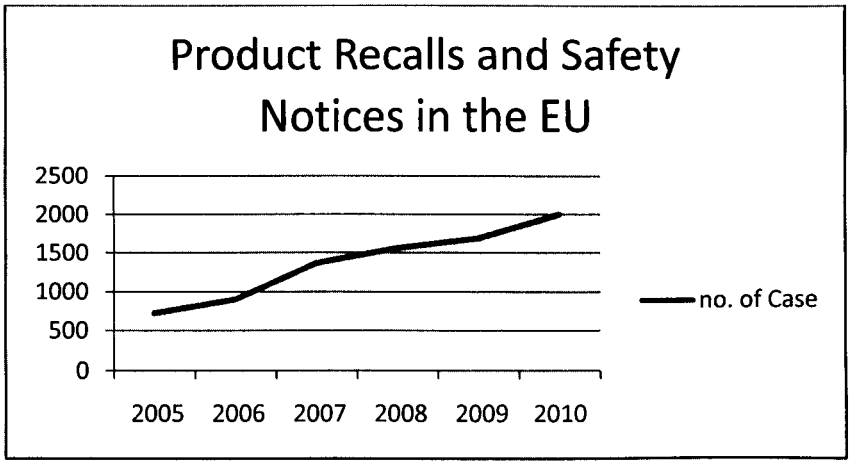

Figure 1.1 The number of product recall cases in the EU (RAPEX, 2011)

Product harm incidents have occurred more frequently in recent years (RAPEX 2011). Heerde *et al.* (2007) claimed that this might be related to the

increased complexity of products and higher customer demands, as well as to closer scrutiny by manufacturers and policy makers. Besides, the global supply chain has elongated which increases uncertainty and adds extra quality considerations to the final products. Marucheck *et al.* (2011) suggested that such problems might be due to changes in global production systems and the increasing complexity of supply chains. Since many firms have moved their production off-shore, it becomes more difficult to assure the quality and safety of their products with such a long supply chain. This phenomenon is also reflected in the statistics of product recalls in the EU. In 2010, more than half of consumer product recall cases in the EU were made in China (RAPEX 2011). In these product recall scandals, all the parties including the governments, consumers and manufacturing firms, would like to promptly remove the defective/unsafe products from the marketplace (BRC 2007). Product recalls tend to cause mainly major consumer panic, which is very costly and detrimental to firms (Heerde *et al.* 2007).

Contaminated and unsafe products could occur in more and more manufacturing industries unless precautions are taken. In 2007, high levels of industrial toxins were found in exports ranging from toothpaste to toys (Bogdanich 2007, Roth *et al.* 2008, Yang *et al.* 2009). Mattel recalled more than 21 million Chinese-made toys worldwide because the products contained lead paint or tiny,

detachable parts that could easily be swallowed. In 2009, contaminations have also been found in sausages, pizza, ready meals, and other products made with dioxin Irish pork. Table 1.1 shows some examples of recent product recalls:

Table 1.1 Some of the product recalls in recent years

Product	**Country of origin**	**Recall took place at**	**Year**	**Descriptions**
Sausages, pizza, ready-made meals containing pork	Ireland	EU & UK	2009	Irish pork products were contaminated by dioxin. The source of dioxin was found in the animal feed in the pig farms.
Toxic drywall	China	US	2009	Chinese made drywalls used in house interiors were found to contain toxic level of pollutants, such as sulfur.
Salmonella Peanut products	US	US, South Korea, Canada	2009	Peanut Corporation of America distributes contaminated peanut butter to 70 consignee firms as ingredient for cookies, cracker, ice-cream, etc.
Toxic sofa	China	UK	2008	Argos, Homebase and Land of Leather recalled their toxic sofa due to DMF being added to the leather surface during storage.
Flaming laptop computer	China, Japan	US	2006, 2008	Apple, Dell, Toshiba and HP recalled the overheating batteries which were purchased from Sony.
Mattel lead toy	China	US	2007	High level of lead was found on the tainted toys because of lead paint used by the outsourced vendor.
Plasticiser drink	Taiwan	US, Taiwan, China	2011	Massive of bottled drinks are contaminated by a toxic plasticizer – DEHP, as DEHP is used as a substitute of the emulsifier - a food additive often used in bottle drinks.

Such a rapid increase in product harm scandals in the global supply chain not only new challenges to the policy makers and industrialists, but also new research

issues and opportunities to the academic world, especially to the field of supply chain management. The research related to supply chain quality risks (SCQR) provides an opportunity for many researchers to investigate and extend the existing risk management and quality management theories and frameworks. However, in the literature, the supply chain risk management practices associated with such quality and safety issue are only partially understood and assessed (Marucheck *et al.* 2011, Roth *et al.* 2008).

These SCQR are aggravated by the significant increase in the depth of global sourcing of materials and in the magnitude of the outsourcing production of branded products to contract manufacturers (Roth *et al.* 2008). Hence, supply chain risk management (SCRM) has become vital to successful supply chain operations. In recent years, the scientific contribution to SCRM has stressed the key role of managing the operational risks in multilayered supply chains (Norrman and Jansson 2004, Tomlin 2006, Yang *et al.* 2009). Researchers have developed a number of risk management decision models to manage SCQR. Some research has focused on the contract design issue that the supplier is penalized when the customer seeks compensation for damage, non-delivery and defects (Baiman *et al.* 2000, Balachandran and Radhakrishnan 2005, Yang *et al.* 2009). Some scholars have studied product recall management in which the product recall strategy and recall

time is well planned in order to reduce the impact of SCQR (Kumar and Budin 2006, Kumar and Schmitz 2011, Gray *et al.* 2011).

The severity and complexity of the product quality problem have been aggravated due to the magnitude of the global sourcing issue. Most companies now include global sourcing as part of their procurement strategy. This results in a long supply chain which often cuts across various regions. It is not surprising that more than half of the production of branded products is outsourced to vendor plants. The product quality problem accumulates when these vendor plants also outsource some of the jobs to other vendor plants and the process may continue (Lyles *et al.* 2008). Figure 1.2 illustrates the situation where the quality uncertainties accumulate across the supply chain. If more members join the supply chain, more uncertainties accrue regarding the quality of the final product. In such a complicated and multilayered supply chain environment, firm executives may fail to anticipate the cascading effect, that occurs routinely throughout their supply chain operations (Lamarre and Pergier 2009). In fact, there is no easy formula for anticipating the way that quality risk cascades through a supply chain.

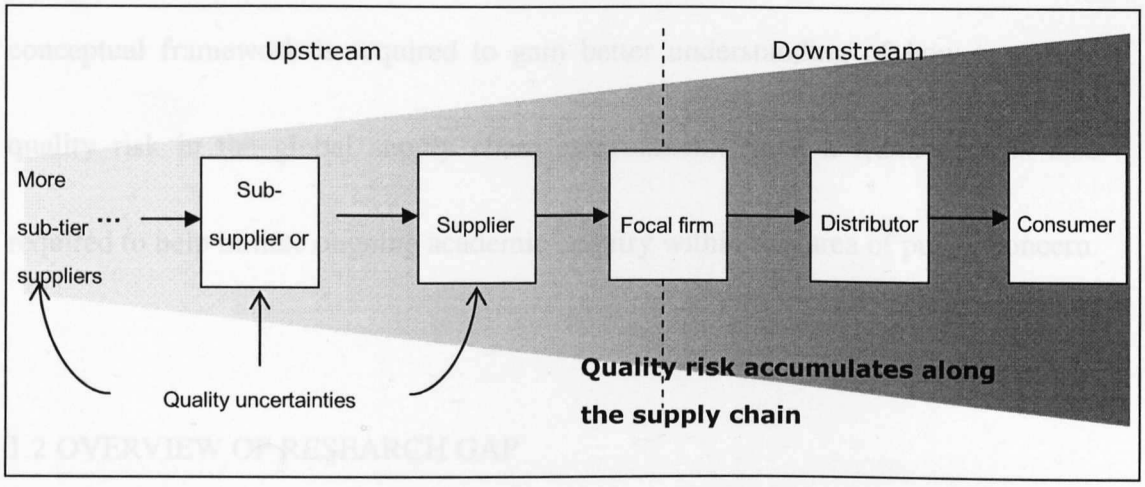

Figure 1.2 Quality uncertainties accumulate along the supply chain

Knowing how to handle quality risks through proper risk management practices is definitely important for firms who wish to sustain themselves or compete in the market. What is vital is how to manage and control quality risks (i.e. preventing defective or unsafe products from reaching the customer). Thus, firms and policy makers face the challenging question: What systems are appropriate to manage and control the risks to product quality in the global supply chain in the short and long run?

Although risk management principles are well understood and clearly described in the supply chain disruption risk management and strategy literature (Tang 2006, Rao and Goldsby 2009), the way to manage quality risk in complex international supply chain operations and the significance of risk in the context of a global supply chain has barely been researched (Marucheck *et al.* 2011). In the absence of sufficient literature, a supply chain quality risk management (SCQRM)

conceptual framework is required to gain better understanding of how to reduce quality risk in the global supply chain environment. Such a framework is also required to help initiate ongoing academic enquiry within this area of public concern.

1.2 OVERVIEW OF RESEARCH GAP

Although SCRM has gained attention in the academic area (Thun and Hoenig 2011), the research effort in theory construction of SCRM is nevertheless meager. In recent years, some related studies have emerged (Marucheck *et al.* 2011, Lewis 2003, Zsidisin and Ellram 2003, Thun and Hoenig 2011). However, most of them are prescriptive, aimed at encouraging practicing managers to promote the use of SCRM[1] in organizations, and citing the expected benefits in managing disruption risk in the supply chain and reducing the impact of supply insufficiency. Little empirical effort has been made to scrutinize the concepts of solving supply chain quality risk (SCQR).

The neglect of SCQRM can also be found in organizations where relatively little attention is given to the SCQRM in reducing quality risk from the upstream supply chain. Most of the literature examines the quality issues, including product defects, contamination, and unsafe products, in the light of quality management

[1] The definitions and relationships of SCRM, SCQR, SCQRM are clearly mentioned in Section 2.1 and illustrated in Figure 2.1

principles and practices.

In summary, the research gaps are consolidated and presented as follows:

(i) Firstly, although it is widely accepted that SCQRM involves risk prevention and control (Marucheck *et al.* 2011, Thun and Hoenig 2011, Lewis 2003), the bias towards the prevention/control aspect in research may lead to the need to allocate the responsibilities (economic loss) between buyer and seller being neglected. Moreover, the literature fails to unfold the multi-dimensional nature of SCQRM. As a result, a formal definition which captures its multi-dimensional characteristics, in the form of a measurement construct has not yet been developed. Thus, a comprehensive framework of SCQRM which reflects the multi-dimensional content of SCQRM is needed for academics and practitioners to gain a better understanding of SCQRM.

(ii) Secondly, the validated measures of SCQRM practices have rarely been used in past empirical studies related to SCRM/SCM. As part of this, although operations management (OM) researchers have framed *SCQR* as a key component in their SCRM tools and frameworks (Hwang *et al.* 2006, Zsidisin and Smith 2005, Zsidisin and Ellram 2003, Zsidisin 2003b, Zhu *et al.* 2007, Zsidisin *et al.* 2000, Baiman *et al.* 2000), the measures of SCQRM have not been examined empirically with large scale data. As a result, there has been no any systematic attempt to develop a valid measure that reflects the multi-dimensionality of SCQRM.

(iii) Thirdly, the value of SCQRM, as described in recent literature, is quite determined predominantly by its contribution to product recall management and product recall's effect on organizational performance (Hora *et al.* 2011, Thirumalai and Sinha 2011). The impact of this bias is that the link between a comprehensive conceptualization of SCQRM and firm performance is still lacking. Moreover, the association link between SCQRM and product quality is still not fully scrutinized in the literature.

1.3 RESEARCH QUESTIONS

In order to contribute the research gap (i), (ii) and (iii), three research questions are identified:

- RQ1) What should SCQRM entail in order to reduce the risk to the quality of products being handled along the supply chain?
- RQ2) What would a valid measurement scale of SCQRM entail?
- RQ3) What is the impact of SCQRM on product quality and firm performance?

This study strives to answer these three research question in order to contribute to the knowledge in the area of SCRM. In RQ1, it aims to contribute in developing a comprehensive SCQRM conceptual framework that addresses the

research gap (i); In RQ2, it aims to develop measurement instruments of SCQRM that addresses the research gap (ii); Finally, in RQ3, it aims to investigate the performance effect of SCQRM in terms of product quality and firm performance. Thus, it can contribute to research gap (iii).

1.4 SCOPE OF RESEARCH

The aim of this research is to conduct an empirical study in SCQRM to reduce the risk to product quality only. The study does not include other supply chain risks, such as demand risk, disruption risk, and reputational risk. Also, the research scope does not aim to develop supply chain risk management for solving problems related to all kinds of supply chain risk, as the generic supply chain risk management practices are well documented in the literature. This study focuses on the development of measurement instruments of SCQRM and its impact on performance, including the following issues:

- To conceptualize and operationalize SCQRM for reducing quality risk
- To propose SCQRM dimensions in reducing quality risk
- To develop a scale for the measurement of SCQRM
- To validate the SCQRM measurement scale through robust empirical tests
- To investigate how the SCQRM practices impact on product quality and firm

performance

1.5 CHAPTER OUTLINE

The remaining chapters are arranged as follows:

Chapter 2 provides a review of the literature on the definitions and on the evolution of risk, risk management and risk management in supply chains.

Chapter 3 contains a description of various aspects of the research methodology applied in this research. Survey-based research methodology is used to analyse the collected primary data. This chapter provides an overview of various methodologies adopted in this study, including, Exploratory Factor Analysis (EFA), Confirmatory Factor Analysis (CFA), Structural Equation Modeling (SEM), and the scale development process.

Chapter 4 aims to conceptualize and operationalize SCQRM. By consolidating the literature review, four SCQRM dimensions are proposed. This chapter focuses on – how to broaden the concept of SCQRM, clarify its purposes, identify the SCQRM dimensionality, scrutinize the activities in each dimension and generates the potential

measurement items that can represent each dimensional construct.

Chapter 5 contains a discussion of the scale development process of SCQRM and shows the results. After conceptualizing SCQRM dimensions and their measurement items, well-proven scale development procedures (Menor and Roth 2007, Hinkin 1995, Rungtusanatham 1998, Rungtusanatham *et al.* 1999) are conducted for assessing the validity and reliability of measurement items. Thus, a set of well-defined, valid and reliable measurement scales of SCQRM can be obtained.

Chapter 6 contains an assessment of the effect of SCQRM on company performance. It is important to explore how the various SCQRM dimensions influence the product quality and firm performance. Two models are developed for examining the performance outcomes of adopting SCQRM practices individually and collectively.

Chapter 7 contains a summary of the findings and contributions.

CHAPTER 2. LITERATURE REVIEW

2.1 INTRODUCTION

As mentioned in Chapter 1, supply chain quality risk management (SCQRM) is an important management approach since it can reduce quality risks, and mitigate any catastrophic consequences which are propagated along the downstream supply chain. In principle, risk management (RM) is the core element in any competitive strategy (Bettis 1983). Amit and Wernerfelt (1990) mentioned that "*the theorist depicted the management of business risk as central to organizational evolution, a determinant of which organizations survive and grow and which decline and die*". Amit and Wernerfelt (1990)'s quote explicitly spelt out the importance of RM impact on organizations. Hollman and Forrest (1991) stated that "*RM contemplates elimination and reduction of potential losses and/or the financial losses if and when they occur*" Also, RM can be broadly applied to individuals and business entities in various disciplines, ranging from product management, project management, as well as supply chain management (Hollman and Forrest 1991, Kouvelis *et al.* 2006).

After the mobile-phone giant, *Ericsson* suffered a loss of US$400 million in sales from a serious supply disruption in the Albuquerque incidents in 2000, SCRM has attracted the attention of scholars and industrialists (Christopher and Lee 2004, Norrman and Jansson 2004, Matook *et al.* 2009, Manuj and Mentzer 2008,

Marucheck *et al.* 2011). The good manager adopts different systematic risk management approaches to deal with different kinds of supply chain risk (SCR) in a more effective and efficient manner, for the sake of the organization and its business partners (Norrman and Jansson 2004). Although there is already some research related to SCRM presented in the recent literature, the research effort of reviewing SCRM is nevertheless meager. Especially, SCRM studies related to managing supply chain quality risk (SCQR) are particular lacking. In this chapter, the concept of SCQRM is critically reviewed and a comprehensive overview of SCQRM research is presented. For having a better understanding of SCQRM, this chapter firstly describes the major terminologies so as to clarify the core concepts and provide an unambiguous definition of SCQRM. Thus, the SCQRM related literature, including risk, supply chain management (SCM), Quality Management (QM), SCR, RM and SCRM, is critically reviewed. The evolution and definition of RM are examined, since development of SCRM is believed to be philosophically based on the literature of RM. Moreover, SCRM is an integrated concept of SCM and RM. Therefore, an overview of SCM is also provided in this literature review. Moreover, there is a need to have a thorough understanding of risk, SCR and SCQR before the concepts of RM and SCRM and SCQRM are scrutinized. Hence, the research gaps of SCQRM in solving quality risk can be identified after the literature concerning risk, SCR, SCM,

QM, RM, and SCRM have been comprehensively reviewed. Figure 2.1 shows the structure of the literature reviewed in this chapter. As shown in the figure below, SCRM is an intersection of SCM and RM concepts. Moreover, SCQRM is an intersection of SCM, RM, QM and SCQRM is a subset of SCRM. On the other hand, SCQR is the sub-set of SCR in which SCR is a sub-set of the risk concept.

This chapter is structured into five main sections. In section 2.2, risk is explained and defined. In section 2.3, SCR and SCQR are discussed and defined. Section 2.4 and 2.5 contain a review of studies related to SCM and QM respectively. In section 2.6, the literature review of RM is included. Recent literature related to SCRM is reviewed in section 2.7. Also, the definition of SCQRM is identified and discussed. Furthermore, *agency theory*, *complementarity theory*, *resource-based view theory, resource-dependency theory and transaction cost exchange theory* are reviewed and discussed in sections 2.8. These theories are included in the literature review as they are adopted in supporting SCQRM arguments in later chapters. Finally, section 2.9 contains a definition of the research gap, and this chapter is concluded in section 2.10.

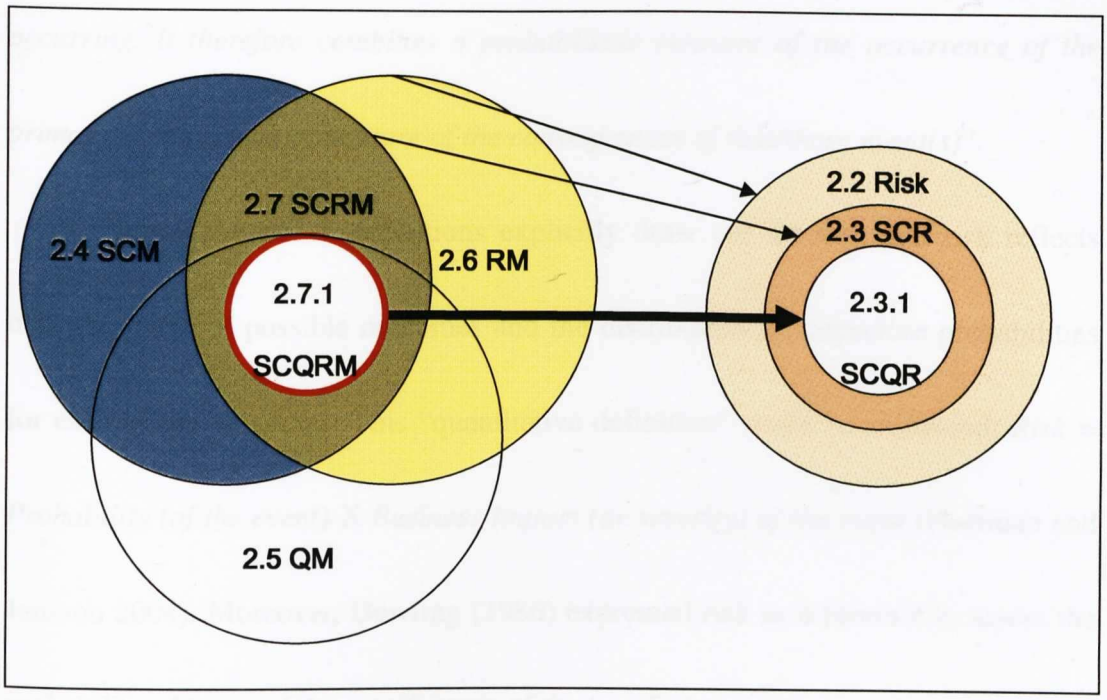

Figure 2.1 Illustration of the structure of the Literature Review

2.2 RISK

Risk is generally described as a situation which would lead to negative consequences, and has a certain level of probability to occur. Dowling (1986) stated in the perspective of the decision theorists: "*risk is the situation where a decision maker has a priori knowledge of both the consequences of alternatives and their probabilities of occurrence*". Others developed another, scientific perspective of risk, such as Mitchell (1995) and Gillet (1996). Mitchell (1995) defined risk as "... *the probability of loss and the significance of that loss to the organisation or individual*". A more standard definition of risk is provided by The Royal Society (The Royal Society 1992): "*Risk is the chance, in quantitative terms, of a defined hazard*

occurring. It therefore combines a probabilistic measure of the occurrence of the primary event(s) with a measure of the consequences of that/those event(s)".

Hence, the above definitions explicitly draw out the fact that risk reflects both the range of possible outcomes and the distribution of respective probabilities for each of the outcomes. This "quantitative definition" could be expressed: *Risk = Probability (of the event)* X *Business Impact (or severity) of the event* (Norrman and Jansson 2004). Moreover, Dowling (1986) expressed risk as a formula to assess the probability of loss and the significance of the loss for an event:

$$Risk = Probability\ of\ loss\ (i) \times Importance\ of\ loss(i) \quad (2.1)$$

Dowling (1986) claimed that the loss was multi-faceted in nature, in that it included one or more of these types of loss: performance, social, physical, financial, psychological, psychosocial, time, frustration.

Moreover, some scholars stated that risk was a manifestation of *uncontrollability* rather than merely a downside possibility (Rao and Goldsby 2009). Sitkin and Pablo (1992) defined that: risk is the extent to which there is *uncertainty* about whether potential significant and/or disappointing outcomes of a decision will be realized. Moreover, Dowling (1986) defined risk as a two-dimensional structure, which included two elements: *uncertainty* and *adverse consequences*. Dowling (1986) further expressed his definition into an equation, where uncertainty indicated the

degree of uncertainty and adverse consequences indicated the degree of loss:

$$Risk = Uncertainty(i) \times Adverse\ Consequences(i) \qquad (2.2)$$

Both equations 2.1 and 2.2 express the characteristics of an information-processing view of considering risk during decision making. Also, Dowling (1986) further explained the theoretical arguments for choosing a multiplicative relationship in the equation: (i) the absence of either variable would eliminate risk; (ii) the risk is reduced while the effect of adverse consequences (or loss) becomes insignificant.

The "quantitative definition" (in equation 2.1 and 2.2) can bring a more business-oriented and a broader view of risk, however, it also makes the term "risk" become much fuzzier (Norrman and Jansson 2004). Although "Risk" can be calculated from an equation theoretically, the "uncertainty" is still generally hard to quantify. Williams *et al.* (2006) stressed that "*uncertainty describes the situation in which the probability cannot be attached and where elements of the environment may not be predictable*". However, it is still worth examining the concept of risk separately: (i)risk source (equal to uncertainty) and (ii) risk consequence (equal to risk impact), as the term, "risk" can be confusing to the manager (Jüttner *et al.* 2003).

Thus, for having a more comprehensive view of risk, the scholars and practitioners view risk as a multi-faceted concept. For example, strategic researchers divided risk into two dimensions: systematic risk (which captures the variation in

stock return ascribable in market-wide forces); and unsystematic risk (which reflects the variation in stock return ascribable in firm-specific forces) (Amit and Wernerfelt 1990, Miller and Bromiley 1990). Moreover, Smith and Merritt (2002) stated that risk should comprise dimensions of the impact of possible outcomes, the ranges of possible outcomes, the source of possible outcomes, and the possibility of occurrence of these outcomes. Sitkin and Pablo (1992) stressed that researchers should not overlook the multi-dimensional nature of risk as it was essential for understanding risk. They identified three dimensions of risk: outcome uncertainty, outcome expectation, and outcome potential. By thoroughly studying the dimensions and factors of risk, researchers and industrialists can have a better initiation point to kick start RM activities and setup appropriate strategies.

2.3 SUPPLY CHAIN RISK

In this decade, there have been several industrial trends to develop new supply chain strategies in the new business environment. For example, increase in strategic outsourcing, increase in the globalization of the market, increased reliance on suppliers for specialized capability and innovation, increased reliance on the supply network for achieving corporate competiveness, and the emergence of information technology for extending supply chain collaboration (Narasimhan and

Talluri 2009). These trends also provide new strategic options for the firms, however, they also increase the probability that firms may have to face new threats in their business operations - i.e. supply chain risks (SCR).

Therefore, scholars have expanded their studies of risk from the firm level to the supply chain level. SCR is complicated to manage, as it may not only affect a single firm, i.e. a cascading effect can be formed across the supply chain when SCR is triggered. In this study, Zsidisim (2003a)'s definition of SCR is adopted: "*Supply Chain Risk is the distribution of outcomes related to adverse events in a supply chain, that affect the firm' s ability to meet customer demand, in terms of both quality and quantity, within an anticipated cost and period of time, or cause threats to customer life and safety*".

Moreover, SCR is usually linked with the uncertainty which is inherent in all supply chains. Tang (2006) associated SCR with various uncertainty variables in upstream, downstream and focal firms. Jüttner (2003) claimed that SCR originated from the uncertainties from the external supply chain, the internal supply chain, and from network related uncertainty. In the SCR review study of Rao and Goldsby (2009), they categorized SCR into environmental risk, industry risk, organizational risk, problem-specific risk and decision maker risk. All these different types of risks were constituted by various uncertainty variables.

Tang (2006) further categorized SCR into two main categories: operational risk and disruption risk. Operational risk includes demand uncertainty, supply uncertainty and cost uncertainty. Disruption risk relates to major supply chain interruption and refers to natural and man-made disasters. Moreover, Manuj and Mentzer (2008) grouped SCR into three categories: operational risk, demand risks, and security risk. In addition, Jüttner (2005) proposed a risk category that included three types of SCR: environmental risk, supply risk and demand risk. In Table 2.1, the works from recent literature from Manuj and Mentzer (2008), Matook *et al.* (2009) and Tang and Musa (2011) have been consolidated to form a detailed overview of different types of SCR.

Table 2.1 Types of supply chain risk

Risk Type	**Description**	**Previous research**
Price risk	Risk that the variation in price of raw material impacts on the firm's competiveness	Zsidisim *et al.* (2004); Matook *et al.* (2009)
Demand risk	Risk that the customer demand is unpredictable and unstable	Jüttner *et al.* (2003); Tang (2006); Manuj and Mentzer (2008)
Disruption risk	Risk that the supplier fails to deliver the required quantity	Zsidisim *et al.* (2003a); Zsidisim and Ellram (2003); Jüttner *et al.* (2003); Craighead *et al.* (2007)
Quality risk	Risk that the production of the supplier does not meet quality specifications	Zsidisim *et al.* (2000); Zsidisim and Ellram (2003); Manuj and Mentzer (2008); Gray *et al.* (2011)
Technology risk	Risk that technology issues affect the stability of the supply chain	Zsidisim *et al.* (2000); Zsidisim and Ellram (2003); Jüttner *et al.* (2003)
Economic risk	Risk that relates to financial and economic issues, e.g. financial issue leads to supply interruption, or bankruptcy of supply chain	Zsidisim *et al.* (2000); Kleindorfer and Saad, (2005); Manuj and Mentzer (2008)

Risk Type	Description	Previous research
	partner.	
Environmental risk	Risk that arises from interactions with supply chain environment, such as disasters, accidents, political actions.	Jüttner *et al.* (2003); Kleindorfer and Saad, (2005); Kouvelis *et al.* (2006); Rao and Goldsby (2009)
Outsourcing risk	Risk that relates to undesired outcomes from transferring previous in-house production activities to a third party.	Lonsdale (1999); Handley and Benton Jr. (2009)
Inventory risk	Risk that relates to excessive inventories, which leads to unnecessary warehouse handling costs, and capital investment.	Zsidisim *et al.* (2003a); Manuj and Mentzer, (2008)
Reputation risk	Risk that relates to a range of possible losses in reputational capital.	Fombrun *et al.* (2000); Roberts (2003)
Logistics risk	Risk that arises from logistics issues which results in a delay in the delivery of products/raw materials.	Cavinato (2004); Craighead *et al.*, (2007)
Labour risk	Risk that relates to human resources in supply chain partner, and shortage/high turnover rate of quality employees.	TheMcKinseyQuarterly, (2006); Liu *et al.* (2009)
Operational risk	Risk that relates to outcomes related to adverse events within the firm that affect its internal ability to produce quality goods on time, and/or its profitability.	Manuj and Mentzer (2008)
Security risk	Risk that relates to negative outcomes related to issues that threaten human resources, operation integrity, and information systems which may lead to threats such as freight breaches, stolen data and/or proprietary knowledge.	Manuj and Mentzer (2008)

Moreover, the SCR in the product harm scandals mentioned in Chapter 1 is related to quality risk in the supply network. Subsequently, this is only a part of SCR. However, supply chain quality risk (SCQR) can be the initial point of a serious risk

consequence as SCQR can trigger other types of SCR. When SCQR occurs in a firm, it can also cause a disruption risk, financial risk, and reputation risk. Also the SCQR can be propagated by the domino effect across the supply chain. To ensure a more accurate description of a research gap in this study, a clear definition and the uncertainty factors of SCQR are provided in sub-section 2.3.1.

2.3.1 Supply Chain Quality Risk

2.3.1.1 Definition of Supply Chain Quality Risk

Quality risk is viewed as a product harm crisis in which there are "*discrete, well-publicized occurrences wherein products are found to be defective or dangerous*". As such a product harm/safety problem is viewed as the most serious type of quality defect. These cases have been well documented in the marketing literature (Dawar and Pillutla 2000, Siomkos and Kurzbard 1994, Heerde *et al.* 2007, Chen *et al.* 2009). In more recent research, Gray *et al.* (2011) defined quality risk as "*the propensity of a manufacturing establishment to fail to comply with good manufacturing practices*".

In this study, the quality risk is focused in the *supply chain context*. Figure 2.2 illustrates the concept of SCQR. Assuming there are three supply chain members in a supply chain: A, B and C: A finds a quality problem and discovered the cause of it after a time period. However, the defective materials have already been distributed

to the downstream members. The perspectives of this event in different supply chain members will be:

- *Supply Chain Member A: It is a quality problem in production (Internal problem from A's view).*
- *Supply Chain Member B: It is a component/raw-material quality problem from Supplier A(External problem from B's view)*
- *Supply Chain Member C: It is a material/component quality problem of Supplier B. In fact, it is a sub-tier supplier problem from its supply networks*

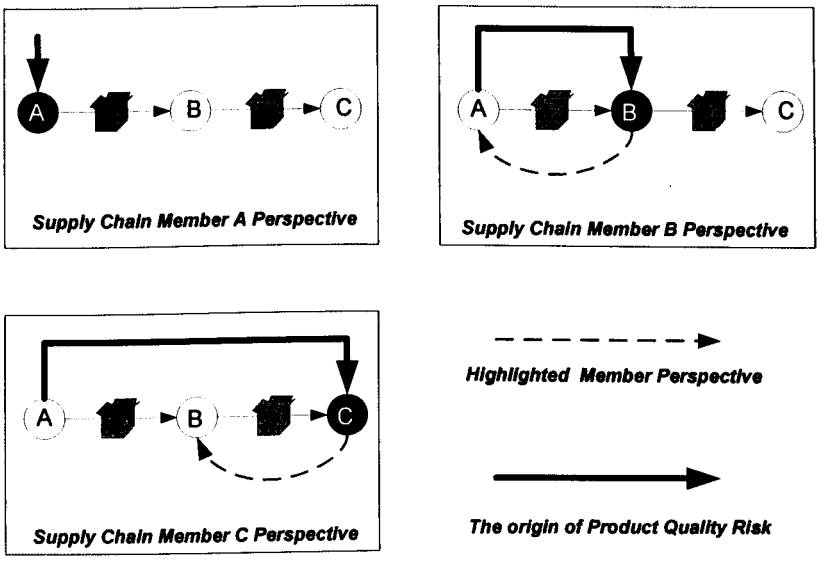

Figure 2.2 An illustration of the concept of quality risk in a supply chain

Quality risk in a supply chain focuses on the quality problems in the supply chain context, rather than in the manufacturing quality context. Thus, the definition

of-SCQR can be seen as:

> *Inherent quality uncertainty of raw materials / ingredients / production / logistics / packaging in any of the supply members triggers a cascading effect that spreads through a multi-tier supply network.*

Since supply chains are extended by outsourcing and stretched by globalization (Yang *et al.* 2009), it is very hard for firms to manage the material quality of a long or "deep" supply chain. Especially, it is a great challenge for the firm to keep track of, 'events, persons, place and time' in the supply chain and of the final quality of the products (Lyles *et al.* 2008). Moreover, the greater the number of components and sub-components a product consists of the more quality uncertainty is inherent in the supply chain. Components are combined, processed and assembled through a multi-layer supply chain, often with extensive sub-contracting. In view of the above, tracing the quality and safety problem all the way back to the source of defective components/sub-components is extremely difficult (Roth *et al.* 2008). However, the manufacturing firm needs to take the responsibility for the SCQR whether the product contaminates or breaks down due to defects in either the manufacturer's component or the supplier's component (Balachandran and

Radhakrishnan 2005). Thus, firms must explicitly and thoroughly account for uncertainties when they make decisions to source the materials through the global supply network.

In this section, the uncertainty factors in global sourcing by focusing on two dimensions are presented, i.e. (i) the supply chain structural dimension; and (ii) the product design and manufacturing dimension (see Figure 2.3).

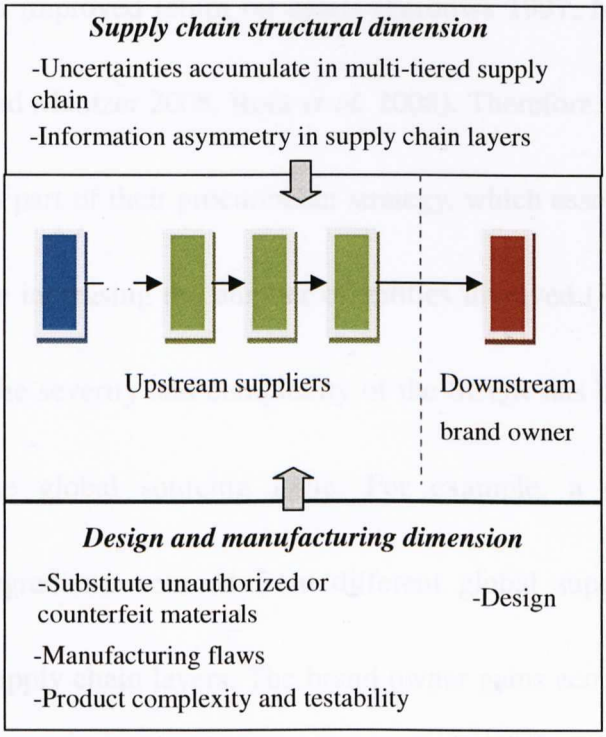

Figure 2.3 Two uncertainty dimensions in supply chain quality risk

2.3.1.2 Supply Chain Structural Dimension

Firms in all industries are able to source from distant locations due to the evolution of internet technology, the efficiency of world-wide logistics networks, and the removal of trade barriers (Nassimbeni and Sartor 2007, Roth *et al.* 2008). Global sourcing provides firms with an access to cheap labour and raw materials, foreign market outlets, better financial opportunities, greater mix and volume flexibility, and an improved return on assets (Ferdows 1997, Nassimbeni and Sartor 2007, Manuj and Mentzer 2008, Roth *et al.* 2008). Therefore, many firms include global sourcing as part of their procurement strategy, which essentially complicates the supply chain by increasing the number of entities involved (Roth *et al.* 2008, Lyles *et al.* 2008). The severity and complexity of the SCQR has been magnified by the magnitude of the global sourcing issue. For example, a chocolate bar consists of several ingredients sourced from different global supply chains with different levels of supply chain layers. The brand owner gains economic benefit by sourcing material / outsourcing production globally, but also comes across a major difficulty in controlling and assuring the quality of materials from supply chains that are located in various countries. In these countries the costs and risks are affected by multiple dimensions of distance factors (i.e. cultural, administrative or political, geographic and economic distance) (Ghemawat 2001).

Moreover, it is not surprising that more than half of the productions of branded products are outsourced to vendor plants. These vendor plants may also purchase the material globally and form long supply chains which often cut across various regions. Thus, the quality related problems may get worse when these vendor plants also outsource jobs to other vendor plants and the re-outsourcing process may continue (Lyles *et al.* 2008). Typically, a global supply chain often consists of five to six tiers, including retailers, wholesalers, distributors, manufacturers and suppliers. They are linked together in a supply network which may stretch over several thousand miles. Including the logistics service providers linking up the members together, that number commonly doubles to approximately a dozen parties which coordinate their efforts to turn raw materials into finished goods and eventually sell them to end-consumers (Lyles *et al.* 2008). Such a long supply chain structure has created several uncertainties and undoubtedly complicated the quality assurance along the supply chain.

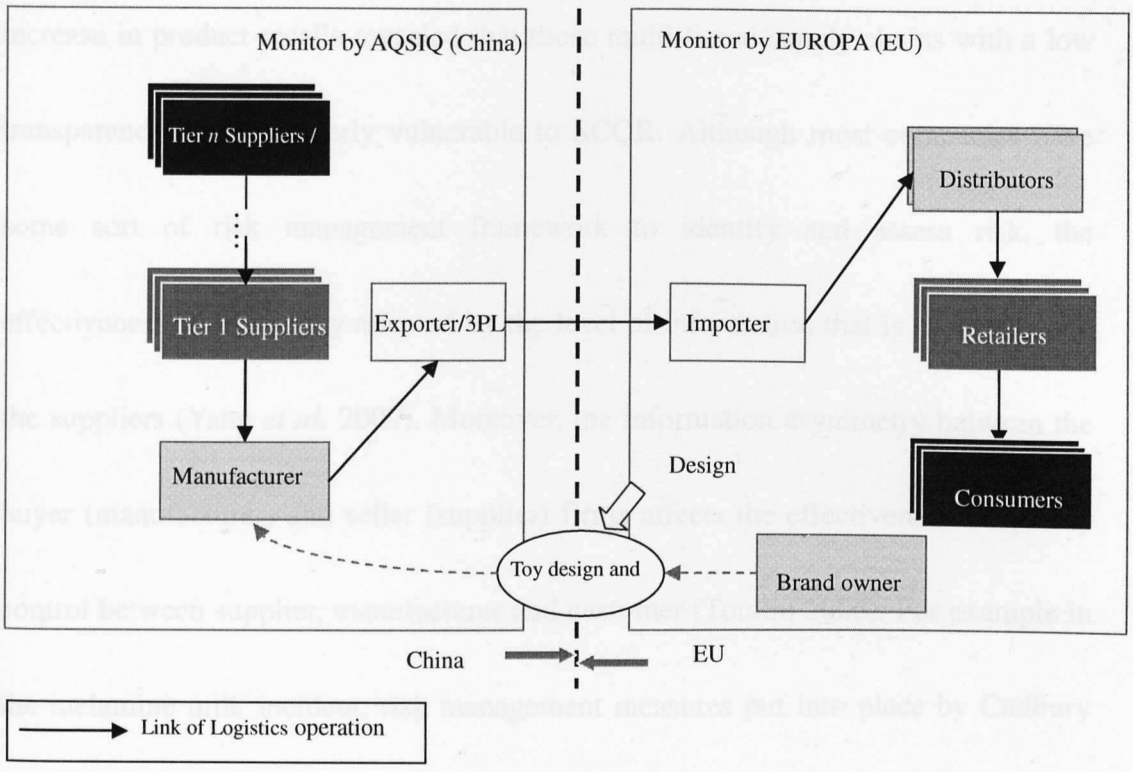

Figure 2.4 An illustration of a typical China sourcing global supply chain

Figure 2.4 illustrates a supply chain crossing China's and Western boundaries. The quality and safety problems and manufacturing flaws can arise in the area of each supply chain member before the material or product is exported. Even during the transition, physical damage can be caused by poor logistics operations in each link between supply chain members. Also, chemical contamination can also happen during storage in both the premises of supply chain members and logistics links. For example, toxic anti-mould chemical (e.g. DMF) can be sprayed onto the surface of the product.

Another uncertainty factor that influences the effectiveness of product quality assurance is poor visibility in the supply chain (Roth *et al.* 2008). The dramatic

increase in product recalls revealed that those multi-tiered supply chains with a low transparency are particularly vulnerable to SCQR. Although most companies have some sort of risk management framework to identify and assess risk, the effectiveness is especially affected by the level of information that is shared among the suppliers (Yang *et al.* 2009). Moreover, the information asymmetry between the buyer (manufacturer) and seller (supplier) firms affects the effectiveness of quality control between supplier, manufacturer and customer (Tomlin 2006). For example in the melamine milk incident, risk management measures put into place by Cadbury Chocolate would probably have been different, if it had known that the dairy supplier had outsourced the milk from individual milk purchasers (which might be unqualified) but not from their own farms. In practice, suppliers often have better information about the likelihood of their experiencing a production quality problem than the manufacturers they serve. This is because suppliers hold private knowledge about such matters as the quality level of the finished goods, the quality audit of their suppliers, the incoming inspection of materials, etc. However, this information may not be shared with their buyers.

Thus, in the elongated global supply chain, each member of the supply chain could trigger a SCQR. The cascading effect of SCQR could start from the bottom of the chain – raw material suppliers or from the front end customers. The cause could

be just because some of upstream supply chain members have manufactured unqualified/unsafe components or added toxic/contaminated substances. The consequences of the SCQR are sometimes magnified in a catastrophic manner due to the rapid growth of off-shoring, where an elongated supply chain inhibits firms from having full visibility of the standards of the products arriving at their factory.

2.3.1.3 Product Design and the Manufacturing Dimension

In the Mattel toy recall incident, most parties, including media and consumers, assumed that the Chinese suppliers/manufacturers needed to take full responsibility for most recalls. In fact, the Chinese suppliers were only involved in manufacturing the toys, but not in designing them. The responsibility for painting the toys with lead-based paint may lie completely with the manufacturers/suppliers in China, but not the toys with design flaws. Lead-painted toy imports were only responsible for about 10 percent of these recalls (Beamish and Bapuji 2008). The recalls of toys because of design flaws and manufacturing flaws (excluding the use of lead paint) were responsible for the balance (Beamish and Bapuji 2008).

The toy recalls can be distinguished as being caused by a) design flaws, and b) manufacturing flaws. The design flaws included the use of small detachable parts, such as button eyes, beads, sharp edges, and any design features that may cause strangulation. The manufacturing flaws included faulty assembly, poor materials, the

use of toxic chemicals, and contamination during the manufacturing process. The increase in design flaw incidents reflects the misunderstanding of the safety implications of toy design. On the other hand, the increase in manufacturing flaws may be caused by the poor management of the global supply chain (Marucheck *et al.* 2011).

The uncertainties of SCQR are also affected by product complexity. While a product consists of a number of components and sub-components, more quality uncertainty is inherent in the supply chain members. Components are combined, processed and assembled through a multi-tiered and multi-channel supply chain, often with extensive sub-contracting, so tracing the quality and safety problem all the way back to the source of defective components/sub-components is extremely difficult (Roth *et al.* 2008). The manufacturers need to take the responsibility for the product quality and safety problems whether the product contaminates/breaks down due to defects or safety problems in either the manufacturer's component or the supplier's component (Balachandran and Radhakrishnan 2005).

Also, the more complex the product's bill of materials, the harder it is to control the quality of the finished products. Because of this, testability is one of the major factors that affect the SCQR. Since quality testing is the "last line of defense" before the harmful product reaches the marketplace/customers, manufacturers must

either invest in in-house testing or employ a third party inspector to assure the quality of incoming materials and finished products.

However, some products do poorly with respect to testability. For example, contamination by foreign substances not previously encountered (Roth *et al.* 2008). In the incident of Sanlu melamine milk, the buyer firm never expected that an industrial material would be added to a food product by its suppliers. This partly explains why the testing procedures in several supply chain tiers were unable to detect the food contamination problem. Nonetheless, low testability can be mitigated by improving the risk perception and knowledge/information sharing with the supply chain members. For example, the melamine contamination incident was not the first time this had happened in food production. The incident of the wheat gluten imported from China during the Menu Foods Corp. pet-food recalls in 2007 should already have alerted the quality managers and inspectors in food industries and prevented the melamine risk in food production.

2.4 SUPPLY CHAIN MANAGEMENT

Supply chain management (SCM) is the management of an interconnected business network that can enhance the organization's ability to provide the required product or service to the end customer (Chen and Paulraj 2004b). Handfield and

Nichols (1999) defined supply chain management as "*all the activities associated with the flow and transformation of materials from raw extraction phase through to the consumption of goods and services by an end user, along with associated information flows, both up and down the supply chain*". Moreover, Mentzer *et al.* (2001) proposed a more comprehensive definition by reviewing and consolidating a number of supply chain management literatures - "*supply chain management is defined as the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole*". The Mentzer *et al.* (2001)'s definition has extended the SCM concept into a strategic level. SCM does not just concern about the transformation of input materials into finished products across a supply chain. SCM also means the coordination of different business functional units across the supply chain entities to improve the organizational performance as a whole. Thus, Mentzer *et al.* (2001)'s SCM definition can be adopted as a useful frame in while a strategic level of supply chain related activities is conceptualized.

Also, SCM emphasizes the interdependence of organizations working collaboratively to enhance the efficiency of the logistics distribution channel (Shin

et al. 2000, Yeung 2008). The term of SCM originated in the 1980s, and it has gained more attentions from academics and practitioners in this decade. There are numerous SCM studies in the literature; it is a broad concept which includes various management activities. The concept of SCM is discussed broadly under different themes. For example, purchasing and supply (Morgan and Monczka 1996), logistics and transportation (Cooper *et al.* 1997), organizational integration (Hakansson and Snehota 1995), information management (Lee *et al.* 2000). Thus, practitioners strive to find ways to improve the business performance through better use of internal and external capabilities so as to create a seamlessly coordinated supply chain. Moreover, competition in the business world has evolved from having an inter-company base to having an inter-supply chain base (Anderson and Katz 1998, Lummus *et al.* 1998, Chen and Paulraj 2004b). Thus, in the context of SCM, performance is no longer affected by a single firm. The company performance is contributed to by the entire supply chain so that all supply chain members are included (Chen and Paulraj 2004b).

Thus, SCM is an integrative function that covers internal operations, upstream operations and downstream operation (Chen and Paulraj 2004b). For instance, the internal operation involves planning and control in purchasing, production and distribution (Chen and Paulraj 2004b); upstream operations include

supplier involvement in product development and supplier monitoring; downstream operations involve coordination with customers in production and logistics activities. Although the above examples may not cover all the facets of SCM, all these elements are part of SCM. In short, the aim of SCM is to plan and control material flow and information flow in the supply chain in order to satisfy customer focus in terms of satisfying needs and providing timely service. Also, firms can enhance the inter-organizational competitive advantage by streamlining SCM activities from upstream and downstream.

2.5 QUALITY MANAGEMENT

In the past decades, there has been a rapid disseminations of quality management philosophy and quality management practices (Das *et al.* 2000, Yeung 2008). Flynn *et al.*, (1994) defined quality management as "*an integrated approach to achieving and sustaining high quality output, focusing on the maintenance and continuous improvement of processes and defect prevention at all levels and in all functions of the organization, in order to meet or exceed customer expectations*". Ross (1993) defined quality management as an integrated philosophy, requiring managerial proactiveness in various areas. For instance, customer orientation, rework reduction, employee involvement, and supplier relationships. Although the quality

literature has different definition of quality management, the scholars and practitioners still consistently describe quality management as an integrated management philosophy, with "functional and organizational boundary-spanning attributes" (Flynn *et al.* 1994, Das *et al.* 2000).

Quality management is the vital element in obtaining "World Class Manufacturing" approach in which quality management is closely linked with other practices, such as just-in-time, technology management, human resource management (Giffi *et al.* 1990, Flynn *et al.* 1994). Moreover, Flynn *et al.*, (1994) stated that quality management can be conceptualized into two major elements, i.e. quality management practices (input) and quality performance (output). Das *et al.* (2000) consolidated the quality management practices in the literatures, and conceptualized four key quality management practices, including supply chain management, quality resource and evaluation, quality training and customer commitment. These four quality management practices include most of the quality management practices in the literatures (Harris 1995, Powell 1995, Das *et al.* 2000) and validated the multi-dimensionality of these four quality management practices as the key dimensions of quality management.

Moreover, as mentioned in section 2.4., business competition is now extending from firm level to supply chain level (Fawcett *et al.* 2006). In order to gain

the competitive power in supply chain competition, firms require a greater level of supply chain cooperation in quality management. Supply chain quality management (SCQM) is defined as "*a systems-based approach to performance improvement that leverages opportunities created by upstream and downstream linkages with supplier and customers*" (Foster 2008). A few studies have attempted to advance the understanding of SCQM with supply chain cooperation and supplier evaluation (Lin *et al.* 2005, Lo and Yeung 2006, Carvalho and Costa 2007). For instance, Lin *et al.* (2005) included quality management practices, supplier participation and supplier selection, while Lo and Yeung (2006) put supplier selection, supplier development and supplier integration as the components of SCQM. Although these models could address and manage the quality risk indirectly, most of them neglected the evaluation of supply risk embedded in the multi-layer supply chain. They also neglected the need for evaluating the suppliers and sub-tiers performance with actions such as process audits, parts configuration analysis and the integration with regulatory bodies/accreditation bodies.

2.6 RISK MANAGEMENT

Hollman and Forrest (1991) defined RM as the systematic approach to protect the firm's assets and profits by using the firm's resources – physical, financial,

and human capital – to realize certain objectives regarding pure loss exposures. However, it should be noted that risk can never be completely eliminated, and a "zero risk" cannot be proved (Bradley 2003), so some current risk management options for protecting the organization are precautionary and are aimed at risk reduction. Moreover, risk was studied by strategic researchers in the 1980's. There are numerous research studies which address the risk-return trade-off when evaluating corporate strategy (Bowman 1980, Amit and Wernerfelt 1990).

Despite this view, businesses and individuals strive to find ways to trade-off risks and benefits every day and perform some form of balancing of risk and reward (Amit and Wernerfelt 1990, Adams 1995). The way that they make these trade-offs depends on what are deemed to be acceptable levels of risk, the size of the benefit and the attitude of the organisation to risk taking (Adams 1995, Smallman 1996). Some organisations and individuals are highly risk-averse while others are risk-takers (Harland *et al.* 2003).

In general, RM can be categorized into two types: (i) process-based RM, and (ii) strategic-based RM. In the process-based RM, RM is focused on understanding the risk, and minimizing the negative impact by addressing the probability and direct impact (Faisal *et al.* 2006). The understanding of risk involves a structural approach for identifying, evaluating, and prioritizing risk, followed by the planning of

resources to minimize, monitor, and control the probability and impact of undesired events (Smith and Merritt 2002, Keizer 2008). In contrast, strategic-based RM aims to have several strategic moves that can potentially mitigate the risk associated with the uncertainties (Miller 1992). Faisal (2006) and Zolkos (2003) stated that strategic risk planning involved the preparation of contingency plans for various risks which are present inside and outside the organization. Hollman and Forrest (1991) claimed that strategic RM should involve the selection of appropriate operational techniques to alter a loss exposure, i.e. to reduce the possibility of loss, severity of loss, or the period variation of losses. Moreover, the European Foundation for Quality Management (2005) proposed a multi-dimensional RM approach, namely the four "Ts" model: terminate, treat, tolerate and transfer. Williams *et al.* (2006) stated that these four "Ts" can be adopted alone, or two or more can be adopted together, to deal with risk. In addition, Miller (1992) stressed the importance of multi-dimensional treatment of uncertainties.

RM approaches have been widely developed across different fields (Rao and Goldsby 2009). For example, financial RM focuses on when and how to hedge using financial instruments to manage costly exposures to risk (Lu and Neftci 2008). Akintoye and MacLeod (1997) proposed risk management as a strategic approach in construction project management. The methods of risk management strategy take

any one or a combination of risk retention, risk transfer, risk reduction, and risk avoidance. Lewis (2003) catagorised the operational RM control into three mechanisms, including *Ex ante*, In-process and *Ex post*. The *Ex ante* mechanism includes the preventive action that is similar to the quality management notion of "right first time" and error-proofing. The in-process mechanism involves the mitigation action if the risk is unavoidable. The *Ex post* mechanism addresses the management of negative consequences, just as service quality actively considers recovery from quality failure. Moreover, Wang *et al.* (2010) proposed a performance–oriented RM framework for innovative R&D projects. They integrated the techniques of project RM with corporate strategy and a measurement system to improve the success rates of new R&D projects, so as to accomplish corporate strategic goals. From the above literature, it seems that there are various RM approaches developed in different disciplines, but all these approaches have a common goal, i.e. to reduce the uncertainty and threat to the firm, in order to improve the firm's performance.

2.7 SUPPLY CHAIN RISK MANAGEMENT

SCRM is a management philosophy that was virtually born alongside the concept of supply chain management as the uncertainties and risks are inherent in

supply chain management (Kouvelis *et al.* 2006). Although SCRM has been well documented in this decade, there is still no universally accepted definition. Scholars view the SCRM concept from various perspectives. For instance, Narasimham and Talluri (2009) defined SCRM as "*a strategic management activity in a firm that can affect the operational, market and financial performance of the firm*". They claimed that strategic SCRM could improve organizational efficiency and performance by reducing uncertainty in the "*context*" and "*environmental reality*". Tang (2006) defined SCRM as "*the management of supply chain risk through coordination or collaboration among the supply chain partners so as to ensure profitability and continuity*". Tang (2006) offered this definition by providing an extensive review study of SCRM of numerous quantitative models in the literature dealing with the risk associated with supply chains. Hauser (2003) viewed SCRM from a strategic perspective and stated that SCRM was a strategic approach to adjust supply chain management to "*keep an increasing complex process moving efficiently at the lowest cost, without compromising the quality of products or customer satisfaction*". Moreover, Manuj and Mentzer (2008) further provided a comprehensive description and aim for implementing SCRM: it involves the implementation of appropriate risk management strategies via a coordinated approach among supply chain members with the objective of reducing one or more of the following – *losses, probability of*

loss, speed of losses, the time for detection of the events, frequency or exposure. This applies to supply chain outcomes that in turn lead to close matching of actual cost saving and to a greater probability of the desired outcomes occurring. In spite of scholars providing different definitions of SCRM, the central idea of SCRM has not been changed. The key function of SCRM is to reduce the negative consequences of supply chain uncertainty by encouraging supply chain members to engage in strategic management activities which positively affect the *operational, market and financial performance of the firm* (Narasimhan and Talluri 2009).

As stated by Zsidisin and Ellram (2003), complete elimination of risk is unrealistic, and reduction of the probability of a detrimental event occurring is achievable. Thus, SCRM needs the firm to reduce the probability of the occurrence of detrimental supply events, or in case of one occurring, to reduce its impact. In addition, Blome and Schoenherr (2011) identified SCRM as a type of enterprise risk management (ERM) that is outside the internal control of the enterprise, as it involved selecting and managing suppliers, as well as dealing with the risk at the same time. Manuj and Mentzer, (2008) treated SCRM as the process of the identification and evaluation of risk and its consequent losses in the supply chain. Table 2.2 provides a summary of 31 key research papers in SCRM and the core contributions of the research. In the table, the research articles are categorised into

four main types of research: the conceptual, case study, review and empirical research.

Table 2.2 Key research in supply chain risk management

Research Type	**Author (s)**	**Type of supply chain risk (SCR)**	**Description**
Conceptual	Jüttner *et al.* (2003)	SCR*	Authors provided a systematic and structural approach to conceptualize the vulnerabilities and risk in supply chain. Also, authors had adopted Miller's (1992) RM framework to develop a SCRM strategy dimension to mitigate SCR.
Conceptual	Zsidisin (2003a)	Quality risk Disruption risk Technology risk Price risk	Author provided a grounded definition of supply risk to focus on risk source (i.e. individual supplier failures, and market characteristics) and risk outcomes (i.e. inability to meet customer requirements, and threats to customer life and safety).
Conceptual	Cavinato (2004)	Logistics risk	Author discussed the overview of SCR and logistics risk. Author also proposed five risk uncertainties categories (i.e. physical, financial, informational, relational and innovational) that could be involved in the logistics of a supply chain.
Conceptual	Craighead *et al.* (2007)	Disruption risk	Authors investigated the link of supply chain design to disruption risk, the risk mitigation capability of recovery and risk warning.
Conceptual	Tang (2008)	Quality risk	Author examined the risk which is associated with product recall, and proposed a preventive framework to manage product recall incidents.

Research Type	Author (s)	Type of supply chain risk (SCR)	Description
Case study	Harland *et al.* (2003)	SCR	Authors reviewed the definition of risk, and provided a holistic view of risk assessment and management. A 6-stage SCRM process is developed (including map, identify, assess, manage, form strategy, and implement strategy).
Case study	Zsidisin (2003b)	Supply risk[#]	Author identified characteristics of supply risk in the literature, and conducted case studies to examine how purchasing manager perceived supply risk.
Case study	Zsidisin and Ellram (2003)	Supply risk[#]	Authors adopted agency theory to propose behaviour-based RM strategy and outcome based RM strategy. Also, the tendency of firms implementing these two strategies was also examined.
Case study	Norrman and Jannson (2004)	Disruption risk	Authors developed a SCRM framework/tool to identify, evaluate, manage and monitor disruption risk which was inherent in supplier and sub-tier supplier.
Case study	Zsidisin *et al.* (2004)	Supply risk[#]	Authors explored and analysed numbers of supply risk assessment techniques which could be adopted to manage the supply risk proactively.
Case study	Kleindorfer and Saad (2005)	Disruption risk	Authors developed a conceptual framework to scrutinise the cooperation of risk assessment and mitigation that were essential to disruption risk management. Also, the result implied that a well designed strategic management system could reduce the frequency of risk as well as absorb more risk without serious negative impact.
Case study	Zsidisin and Smith (2005)	Supply risk[#]	Authors focused on early supplier involvement (ESI) in product design and stressed that ESI was a useful tool to manage supply risk.
Case study	Faisal *et al.* (2006)	SCR[*]	Authors provided a structural modelling approach to effectively reduce SCR by understanding dynamic among various enablers that could help in the risk mitigation process.

Research Type	Author (s)	Type of supply chain risk (SCR)	Description
Case study	Ritchie and Brindley (2007)	SCR*	Authors proposed a SCRM framework by underpinning existing RM constructs. The authors' framework aims to provide a structural way to examine the relationships between "risk and performance", as well as "risk response and performance". The authors' framework is suitable for dealing with all kind of SCR. *Remarks: it only covers demand, financial and operational risks in the case studies*
Case study	Manuji and Mentzer (2008)	Supply risk# Demand risk Operational risk	Author provided six applicable SCRM strategies (postponement, speculation, hedging, control/share/transfer, security and avoidance) with respect to environmental conditions and three moderators (team composition, supply chain complexity and inter-organizational learning).
Case study	Matook *et al.* (2009)	Disruption risk quality risk, environmental risk, technology risk, price risk, economic risk	Authors developed a five stage supplier risk management framework based on Ritchie and Brindley (2007)'s work.
Case study	Blome and Schoenherr (2011)	Supply risk#	Authors investigated a successful approach to dealing with supply risk and how SCRM shifted during a financial crisis.
Review paper	Tang (2006)	SCR*	Author reviewed various quantitative models in managing SCR. He also classified the reviewed articles into six main areas, i.e. supply management, demand management, product management, information management, and mitigation strategy.
Review paper	Rao and Goldsby (2009)	SCR*	Authors reviewed the literatures in SCRM and constructed a typology of SCR. They also stressed the importance

Research Type	Author (s)	Type of supply chain risk (SCR)	Description
			of uncertainty factors in each type of SCR.
Empirical	Hendricks and Singhal (2005)	Disruption risk	Authors examined eleven years of secondary data of supply chain disruption announcements and its negative impact on the firm's long-term stock price performance.
Empirical	Zsidisin *et al.* (2006)	Supply risk[#]	Authors provided an exploratory study of a supply risk audit instrument. A preliminary set of measurement items of supply risk management was developed.
Empirical	Wagner and Bode (2006)	Demand risk Disruption risk Environmental risk	Authors investigated the relationship between supply chain vulnerability and SCR. Also the study examined the supply chain characteristics that caused the firm's exposure to SCR.
Empirical	Braunscheidel and Surseh (2009)	Disruption risk	Authors examined the cultural antecedents which affected the organizational practice (including internal integration, external integration, and external flexibility) so as to improve supply chain agility and mitigate disruption risk.
Empirical	Liu *et al.* (2009)	Labour risk	Authors discussed high turnover rate affecting the firm's capacity and performance in China.
Empirical	Handley and Benton Jr. (2009)	Outsourcing risk	Authors included strategic risk assessment as an important dimension of strategic evaluation of outsourcing. The research investigated *'relationship management practices'* during the outsourcing process as such practices were the key enablers of outsourcing performance.
Empirical	Ellis *et al.* (2010)	Disruption risk	Authors linked the environmental uncertainty factors with the disruption risk. The causal relationships amongst uncertainty factors, representation of risk and decision-making of changing suppliers were examined by using SEM techniques.

Research Type	Author (s)	Type of supply chain risk (SCR)	Description
Empirical	Thun and Hoenig (2011)	SCR*	Authors empirically examined the preventive and reactive SCRM practices that impacted on firm performance in the German automobile industry.
Empirical	Speier *et al.* (2011)	Disruption risk	Authors examined disruption risk in three high risk products (i.e. food, pharmaceutical and hazardous materials), and studied the supply chain intervention practice to ensure and even improve supply chain security.
Empirical	Gray *et al.* (2011)	Quality risk	Authors assessed the difference in quality risk in offshore and domestic manufacturing plants. The study also provided insights into the effect of major location, geographic distance and industry specific skills on quality risk.
Empirical	Hora *et al.* (2011)	Quality risk	Authors studied the secondary data of US toy product recalls during a 15 year period. The research also examined the time required to recall products, and its relationships with recall strategies, the source of the defect, and supply chain position.
Empirical	Thirumalai and Sinha (2011)	Quality risk	Authors used secondary data to explore the sources of product recalls of medical devices, and investigated firm characteristics that are associated with device recalls. In addition, the financial implications of medical device recalls are empirically assessed.

Remarks:

** SCR indicates that the article did not focus on any specific type of supply chain risk.*

#Supply risk indicates that the article only focused on the risk in the upstream supply network

As shown in Table 2.2, there has been a significant rise in the SCRM area in this decade. Several scholars contributed to clarify our understanding of the nature of SCR and SCRM concepts. Some of them provided a holistic view of SCR and

SCRM (Jüttner *et al.* 2003, Tang 2006, Rao and Goldsby 2009). Some of SCRM focused on a specific type of SCR, such as disruption risk and demand risk (Zsidisin 2003b, Cavinato 2004, Craighead *et al.* 2007, Tang 2008).

Moreover, many SCRM research studies on solving the risks included a process flow with four main stages -- identify, analysis, evaluate, and treatment (ISO31010 2009). Similar structure had also been adopted by many SCM and OM researchers in their SCRM studies. For example, Harland *et al.* (2003) developed the 6-stage SCRM cycle, including map, identify, assess, manage, form strategy, and implement strategy as the main steps of their framework; Matook *et al.* (2009) proposed their 5-stage SCRM framework in upstream supplier risk management; Norrman and Jannson (2004) reported the SCRM framework implementation in Ericsson, which adopted a 4-stage process cycle to proactively manage sub-supplier interruption. On the other hand, Jüttner *et al.* (2003) developed the fresh view of SCRM that RM activities should be an integrated strategic practice, rather than following the traditional SCRM framework. Jüttner *et al.* (2003) adopted the previous Miller (1992)'s RM framework in the international business environment to construct an integrated SCRM framework with four mitigation strategies (i.e. flexibility, avoidance, control and co-operation) to deal with supply chain uncertainty and risk drivers. Williams *et al.* (2006) also proposed a similar view in integrated

RM strategic actions (i.e. 4T's model mentioned in section 2.6), but they claimed such strategic actions should be taken after identifying and evaluating risks.

Moreover, there were several studies to investigate the SCRM techniques in managing particular types of SCR. For example, Zsidisin, one of the pioneers in SCRM research area, mainly examined the risk and RM in upstream supply chains (Zsidisin 2003b, Zsidisin 2003a, Zsidisin and Ellram 2003, Zsidisin *et al.* 2004, Zsidisin *et al.* 2000, Zsidisin and Smith 2005, Zsidisin *et al.* 2006). He critically reviewed the possible uncertainty and risk that happened in upstream suppliers (Zsidisin 2003b, Zsidisin 2003a). Also, he grouped the existing supply risk assessment techniques from the literature and from the industries (Zsidisin *et al.* 2004), and pinpointed agency theory as a foundation of SCRM practices (Zsidisin and Ellram 2003, Zsidisin *et al.* 2004) that could provide a theoretical foundation for understanding how and why firms conduct SCRM. In addition, Zsidisin *et al.* (2006) attempted to propose a set of measurement instruments to measure SCRM adopted in organizations. However, the measurement items are still in a preliminary stage since they have not passed through a robust empirical test, such as a content validity test, exploratory factor analysis test, or confirmatory factor analysis test.

As Table 2.2 suggests there has been a substantial rise in empirical research in the SCRM area in the past few years. Coinciding with an increase of interest,

several scholars have developed alternative viewpoints on the nature of SCRM by using empirical support. Wagner and Bode (2006) conducted a large scale survey research to investigate the items which constituted supply risk, demand risk and catastrophic risk. Also, Wagner and Bode (2006) examined the risks' relationships to supply chain management practices, such as single sourcing and global sourcing. Their study provided an empirical investigation and validation of generic supply chain vulnerability constructs. Ellis *et al.* (2010) focused on investigating disruption risk that the importance of a behavioural approach to risk was considered in their model. Ellis *et al.*(2010) drew transaction cost economic (TCE) theory and resource dependence theory (RDT) to identify characteristics in the supply chain environment that could lead to disruption risk. In addition, Ellis *et al.* (2010) proposed a representation of disruption risk that was similar to equation 2.1, and claimed that magnitude of risk (impact) and probability of risk were associated with overall disruption risk. Although Ellis *et al.* (2010) s' research had clearly illustrated the representation of disruption risk, it did not provide a clear solution of how to mitigate it. Braunscheidel and Surseh (2009) s' empirical study filled this missing gap. In Braunscheidel and Surseh (2009) s' study, a supply chain agility model was proposed. They claimed that market orientation and learning orientation were the antecedents of organisation practices. Also, they emphasised that the

organisation practices (including internal integration, external integration and external flexibility) had a direct impact on supply chain agility. Thus, supply chain agility could effectively reduce the disruption risk in the supply chain.

2.7.1 Supply Chain Quality Risk Management

SCQR can destroy a firm's favorable reputation, cause major revenue and market-share losses, lead to costly product recalls, and devastate a carefully nurtured brand equity (Heerde *et al.* 2007). Because of this, a growing number of researchers are looking into the impact of SCQR on the global supply chain, for example, on the global supply chain's quality management (Roth *et al.* 2008), on brand equity (Dawar and Pillutla 2000), on stock market reaction (Zhao *et al.* 2009), and on marketing effectiveness (Heerde *et al.* 2007). However, the severity of quality and safety risks and their implications (i.e. in a multi-tiered China supply chain) have not been fully explored in the present operations management literature.

Moreover, researchers have developed a number of RM decision models to manage SCQR, offshore manufacturing and penalties levied for supplier non-performance (Yang *et al.* 2009). Some researchers have focused on contractual design issues for obtaining the equilibrium outcome that the amount of penalty are able to cover the cost for non-delivery and defects (Yang *et al.* 2009, Baiman *et al.* 2000, Balachandran and Radhakrishnan 2005); Some scholars have proposed

decision support tools for risk assessment (Norrman and Jansson 2004, Steele and Court 1996) in which the size of the potential quality problem and its effect on business profitability are quantified, to support further decision analysis.

Moreover, there are several research studies in which ways to solve product quality and safety problems are discussed. These problems can be broadly solved by looking at three aspects: (i) design-related issues, (ii) manufacturing-related issues, and (iii) supply chain-related issues (Marucheck *et al.* 2011, Beamish and Bapuji 2008).

From the planning point of view, inappropriate and unsafe design is regarded as a design flaw, causing quality risk. For example, small parts in toys can be swallowed by children and lead to choking hazards, or poor design can cause over heating in electrical appliances. The design-related flaws are well documented in ergonomics literature. The root cause of the quality and safety problem can be reduced by making changes in design and in the design process (Beamish and Bapuji 2008, Hale *et al.* 2007, Marucheck *et al.* 2011).

On the other hand, all inappropriate manufacturing issues, such as, faulty assembly, poor materials, use of toxic chemicals, and contamination are regarded as manufacturing flaws. The manufacturing flaws can be corrected by quality management and process improvement techniques, such as Total Quality

Management and 6-sigma (Kumar and Schmitz 2011, Lee and Whang 2005). Supply chain related issues are associated with material sourcing and manufacturing outsourcing.

In recent years, supply chain quality risk management (SCQRM) has been one of the most widely discussed topics in the empirical research area (as shown in Table 2.2). For example, Gray *et al.* (2011) investigated the SCQR in offshore manufacturing plants and found that the effect of plant location, geographic distance, and the skill level of workers in the offshore plant could affect SCQR. The research provided an overview of the factors of offshore manufacturing that could cause SCQR. Their study suggested that knowledge transfer, including frequent behavioural inspections and rotation of managers from effective domestic plants to offshore plants, can improve SCQR. However, their research did not involve an empirical examination of these SCQRM activities in dealing with SCQR. On the other hand, Hora *et al.* (2011) robustly examined the risk remedy practice when SCQR triggered a destructive product recall in the toy industry. The research investigated the relationships among different product recall strategies, time of recall, and defect type. Thus, managers could understand the nature of different recall strategies (i.e. reactive recall and preventive recall) and learn the best time to trigger the recall. However, the research did not include the investigation of various product

recall management practices impacting on the firm's performance with regard to different recall times and various defect types.

2.8 RELEVANT THEORIES TO SCQRM

In this chapter, five theories are reviewed that these theories are potentially suitable to be adopted for supporting the conceptualization, theoretical development of SCQRM, as well as the data analysis results. The selected theories are: agency theory, complementarity theory, resource-based view theory, resource-dependency theory and transaction cost exchange theory. This section provides an overview of these theories.

2.8.1 Agency Theory

Agency theory deals with the problems of sharing risk among groups and individuals (Arrow 1971, Eisenhardt 1989). The "agency problem" refers to problems related to different parties taking different attitudes towards risk sharing during cooperation between principal and agent. The problem arises in an agency relationship in which the principal is the party which delegates work to agent. Thus, principal and agent can be supplier and buyer respectively in a supply chain.

There are two major concerns in an agency problem: (i) the ultimate goals of the principal and agent are in conflict; (ii) it is difficult or expensive for the principal

to accurately examine what the agent has done (Eisenhardt 1989). The agency problem also reflects the realistic situation that different attitudes are held by the agent and by the principal towards risk. Thus, the two parties may prefer different actions as they have different perspectives on risk. For example, the buyer requires an excellent product from the supplier. However, it is hard for the buyer to perfectly examine the supplier's effort in manufacturing the product, and to make sure there is no opportunistic behaviour on the supplier's side.

In such a case, a researcher can focus on identifying situations when the principal and agent may have conflicting goals, and then develop the appropriate mechanism to limit the agent's self-serving behaviour by referring to agency theory (Eisenhardt 1989). In short, agency theory has reestablished the importance of self-interest and reward in organizational thinking (Perrow 1986). Because of their different role in the business environment, many behaviours and actions of the suppliers are based on the self-interest of the supplier and are not in the best interest of the buyer firm.

2.8.2 Complementarity Theory

The complementarity theory was first introduced by Edgeworth (1881). Edgeworth defined activities as complements if doing (more of) any one of them increases the returns of doing (more of) the others (Milgrom and Roberts 1995, Choi

et al. 2008). The complementarity theory can be used to describe the situation where some of the firm's activities and practices are mutually complementary, thus, these practices tend to be adopted together, with each enhancing the contribution of the others (Milgrom and Roberts 1995, Choi *et al.* 2008).

In the strategic management literature, Davis and Thomas (1993) stated that the total value of a multi-business firm exceeds the sum of the individual values of its business. This is due to the synergy effect that exists among all its various business. The super-additive (or super-modular) *value* synergies exist between business A and B that make their joint value greater than the sum of the stand-alone values (i.e. value (A,B) >value (A)+value(B)) (Tanriverdi and Venkatraman 2005). Choi *et al.* (2008) studied how the complementarity effect of knowledge management strategies impact on organizational performance. Their research supports the theory that knowledge management strategy, that is internally-oriented and externally-oriented knowledge management strategies. It indicates a complementary relationship and forms synergies which have a positive effect on a firm's performance. Milgrom and Roberts (1995) employed the complementarity theory to provide a fresh perspective in the study of manufacturing strategies. They argued that a piece-rate-wages system is only part of a system of mutually enhancing elements. Thus, we cannot simply pick out a single element (i.e. piece-rate-wages

system in their study), and graft it onto a different system without other complementary features and expect a positive result. The wages system may fail to perform if there is no support from a bonus scheme, the ownership structure or from the inventory policy.

In short, the complementarity theory can provide a fresh perspective to the academics and practitioners for looking at organizational strategies and reminds them not to overlook the complementary nature of all the elements involved. The complementarity strategies mutually reinforce each other and affect each other's performance outcome. The complementarity theory can be adopted to explain the situation in which a system of the complementarity practices are greater than the sums of the individuals since the synergistic effect is present in the bundle of practices (Choi *et al.* 2008). It also can explain why failure results in a firm which attempts to imitate a successful strategy from another firm, as that particular strategy may be only part of a complmentarity system.

2.8.3 Resource-based View Theory

In this decade, the resource-based view (RBV) has been adopted in several operations management research studies as it can provide interesting insights to clarify the strength and capability which resides in the company and can lead the firm to obtain sustainable competiveness (Lewis 2000, Priem and Bultler 2001).

RBV advocates that the competitive power of a firm is derived from its ability to assemble and exploit an appropriate combination of resources (Wernerfelt 1984). The term "resource" includes both tangible and intangible assets which can generate unique values. Under RBV, resources can be specific physical resources (e.g. specialized equipment, geographic location), human resources (for e.g. expertise in a specific area), organizational resources (e.g. superior sales force) where these resources enable the implementation of a value creating strategy (Wernerfelt 1984, Eisenhardt and Martin 2000). It seems that resources can be very broad in nature. For example, Barney (1991) stated four critical attributes of a firm's resource: (i) it must be valuable in that it exploits opportunities and/or neutralizes threats in the firm's environment; (ii) it must be rare among the firm's competition; (iii) it must be imperfectly imitable; and (iv) it cannot be substituted strategically. These four attributes can be viewed as indicators to show how heterogeneous and immobile resources are, and also how useful these resources are for generating sustained competitive advantages (Barney 1991).

Recently, many research studies have attempted to adopt RBV to provide a better understanding of competitive advantage in different OM areas. For example, the manufacturing strategy (Paiva *et al.* 2007), lean production (Lewis 2000); internet procurement (Ordanini and Rubera 2008), and supply chain-linkage

(Rungtusanatham *et al.* 2003). In these studies, RBV provides a more fine-grained description so researchers can understand how competitive power is generated through the resources, and how these resources positively impact on a firm's performance.

2.8.4 Resource-dependency Theory

Resource Dependency Theory (RDT) provides an organizational perspective regarding formulation and management of power in inter-organizational relations (Ireland and Webb 2007). Ulrich and Barney (1984) argued that the organizational success from a RDT perspective is determined by organizations who maximize their power. Organizations are viewed as coalitions that alter their organizational structure and patterns of behavior in order to acquire and maintain external resources. Since there are differences in dependencies among different organizations, the differences of various dependencies allow the organization to exert power and influence over another organization. Organizations who lack resources will seek to establish relationships with organizations that hold the required resources, in order to obtain resources. Moreover, the organization will try to reduce its own dependence or increase the dependence power of another organization on them (Ulrich and Barmey 1984), i.e. organization attempt to modify the power relations with other organizations.

In OM literature, RDT has been used to describe and explain phenomenon in buyer –supplier partnerships. Ireland and Webb (2007) adopted RDT to explain how power formed in organizations according to the interdependencies among supply chain partners. Handfield (1993) pinpointed RDT as the core framework to explain the relationship between Just-In-Time purchasing systems and the transaction uncertainty. Ellis *et al.* (2010) employed RDT to describe how the uncertainty factors constitute the disruption risk in supply chains. They argued that increases in dependence on supplier firms also increase the uncertainty in supply chain interruptions. Ireland and Webb (2007) integrated RDT in to their conceptual framework to manage the balance of trust and power within the supply chain uncertainty and risks associated with the behavior underlying cultural competitiveness. In short, RDT can be useful theory to explain how organization can operate on their supply environments to reduce the supply uncertainty (Handfield, 1993). It also suggests the organizations may benefit from limiting their dependence on other organizations in order to lower the risk exposure level.

2.8.5 Transaction Cost Economics

Transaction Cost Economics (TCE) was introduced seven decades ago by Ronal Coase (Coase 1937). Williamson (1975) crafted the perspective of TCE, on order to apply the concept to explaining social science phenomenon. TCE is broadly

adopted to explain and describe the phenomenon in various areas. For example, sociology, organizational theory, law, finance, information systems, and marketing research (Grover and Malhotra 2003).

TCE mainly focuses on the cost issues which are associated with exchange governance by identifying governance mechanisms (Williamson 1991, Ellis *et al.* 2010). TCE takes the notion of "transactions" as the focal point of the theory. In the perspective of TCE, the properties of the transaction determine the governance structure which consists of market, hierarchy or alliance (Williamson 1975)

TCE also has been widely adopted in the area SCM (Choi and Krause 2006). Choi and Krause (2006) viewed transaction costs in SCM as *"a frictional cost of doing business with suppliers"*. They argued that frictions originated from the focal firm's interaction with suppliers to obtain the materials, components, and services. Moreover, the activities related to evaluating suppliers, contracting with suppliers, monitoring suppliers, and enforcing agreements are also identified as potential sources of friction (Dyer 1996). Thus, the core of transaction costs originates at the interface between a focal company and its suppliers in the SCM context. The transaction costs are inevitable while the firm develops and maintains an exchange relationship, to monitor exchange behaviors, and to avoid opportunistic behaviour in an exchange situation (Pilling *et al.* 1994).

Moreover, TCE "lens" can also be useful in gaining insights in SCRM. Firms prefer the supplier where transactions are characterized by a limited need for adaptation, coordination, and even safeguarding. Moreover, the selection of a suitable governance structure usually is driven by asset specificity and the degree of uncertainty (Ellis *et al.*, 2010). These characteristics show that TCE is suitable to explain how uncertainty level in the organization can be reduced.

2.9 RESEARCH GAP

2.9.1 Research Gap in SCQRM

In the field of SCRM, the majority of the investigations focus on the supply-side risk in which all types of risks related to suppliers are considered. There are still areas for exploring other SCR, particularly quality risk, in global supply networks. Since there has been a significant rise in product recall cases in recent years, that means there is a considerable amount of quality risk in the upstream supply chain. It is essential for manufacturers to understand how to manage SCQR with the aim of reducing the probability of risk occurrence and minimize the negative impact on organizational performance, so as to sustain competitive power and create long-term benefits to all members in the global supply chain.

Secondly, SCQRM should be explored in a comprehensive way in order to

develop an effective approach to reduce SCQR. Thun and Hoenig (2011) urged that SCRM practices should include both preventive and reactive approaches since different approaches have their own particular strengths in dealing with various types of supply chain vulnerability. To the best of the author's knowledge, a comprehensive approach for reducing SCQR is still lacking in SCRM literature. Some product recall management studies have been conducted in recent years which have attempted to systematically reduce the SCQR when it occurs (Hora *et al.* 2011, Kumar and Budin 2006, Kumar and Schmitz 2011). However, product recall management is only one facet of SCQRM, which just covers "reactive" action in dealing with SCQR. Therefore, there is a research gap in that there is no comprehensive and multi-facetted approach to SCQRM which covers both reactive and preventive practices.

Thirdly, there is a need for empirical work in the field of SCRM to investigate what the important elements are in each practice in SCQRM. While conducting empirical research in SCQRM, a set of measurement instruments are essential for an in-depth investigation. Zisidism *et al.* (2006) proposed sets of measurement instruments for supply risk management, aiming to provide a scale for researchers to investigate the relationship between supply risk management and supply chain performance, and for managers to take them as audit tools in assessing

how to effectively employ the SCRM tool. However, their measurement instruments are related to "supply risk management" and not focused on SCQRM. Moreover, their measurement instruments are not developed through a robust scale development process and are not validated by a large scale dataset. Thus, the third research gap in SCQRM is the lack of validated measurement instruments.

Another important piece of empirical work in SCQRM is to examine how the important effective SCQRM practices affect an organisation's performance (Thun and Hoenig 2011). In order to reduce the risk of delivering defective product to customer, a key challenge faced by a manager is to know how well the SCQRM performs in dealing with the uncertainties in the supply chain. Hence, examining the relationships among SCQRM practices, quality performance and firm performance is another important research gap that needs to be bridged.

2.9.2 Research Gap in China Supply Chain

In recent years, China has become the largest emerging economy in the world (Zhao *et al.* 2006). At the end of 2010, China overtook Japan as the world's second-biggest economy; it has a Gross domestic product (GDP) of US 5.8 trillion (BBCNews 2011). This rapid increase can be traced back to 2001, the year that China became a WTO member. It was a big step forward in increasing economic exchanges with international trading partners (Zhao *et al.* 2006). The agreement of

the WTO reduced the tariffs and others barriers to foreign competition, and invited western countries to be interested in China as a base of operations and as a consumer market (Jiang *et al.* 2007). China provides a practical way of cutting cost – i.e. by providing cheap labour. China's seemingly endless supply of cheap labour provides a vast amount of cheap supply. Global firms move their production lines to China and seek cheaper materials from China's market. The trends of sourcing and off-shoring to China are transforming the practices in SCM and OM globally (Zhao *et al.* 2007). Jiang *et al.* (2007) further claimed that China became further integrated with the global economy, thus, the global economy was simultaneously digesting China's reverse influence on SCM and OM practices. Therefore, it is fruitful for researchers to explore the SCM and OM knowledge which is suitable for application in China's business environment.

Therefore, China is the ideal context for empirically testing this SCQRM study. As China is such an important player in global manufacturing in nearly all kinds of industries, both academic and industrial areas can benefit from the knowledge contribution of a SCQRM study in China. Moreover, the cost advantage of China's products can be improved by SCQRM. It is also reflected from the high numbers (more than 50%) that most product recalls originate in China (RAPEX, 2011). Yet, despite SCQRM being a recent hot topic in SCM and OM research, we

know relatively little about SCQRM in China, and even less about what elements constitute their RM practices. Also, there is lacking from the literature any description of how firms in the China supply chain use SCQRM and how effective it is. The complexity, turbulence, uncertainties and dynamism of China's supply chain environment require the firm to effectively mitigate the SCQR, so as to enhance the firm's product quality and financial performance. More importantly, with China having an increasing share of the global economy, a closer focus on the SCQRM in China enhances our understanding of SCQRM strategy in China, and also makes a contribution to the Chinese firms in that they are enabled to deliver world class quality products. Hence, there is an urgent practical need to shed further light on SCQRM practices in this Chinese supply chain.

2.10 CHAPTER SUMMARY

The chapter analyses the existing literature and reveals research gaps in the field of SCQRM. Separate sections describe and differentiate what risk, SCR, QM, RM, SCM, and SCRM, are, with explanations and definitions. The aim is to introduce and clarify the concepts of SCQR and SCQRM. Also, agency theory, complementarity theory and resource-based view theory have been discussed in this chapter, since these theories will be pinpointed in the theoretical development

sections in the following chapters. Moreover, the research gaps of SCQRM are further explained and elaborated in section 2.9.1 after the literature has been critically reviewed. This section provides further supports for identifying the three key research gaps in section 1.2, and provides further justifications to the relevancy of the three research questions mentioned in Section 1.3 in the previous chapter.

CHAPTER 3. METHODOLOGY

3.1 INTRODUCTION

In this chapter, the methodology of this SCQRM study is described. Methodology can be claimed to be a research strategy in which epistemological and ontological principles are turned into rules which show how the research is being conducted (Lather 1992, Sarantakos 2005). In general, ontology can be defined as "*the study of reality or things that comprise reality*", and epistemology can be defined as "*a theory of knowledge concerned with the nature and the scope of knowledge*" (Slevitch 2011). During the research process, the scientific investigation was characterized by philosophical and meta-theoretical assumptions which concern the nature of reality (ontology) and knowledge of that reality (epistemology), and the particular ways of knowing that reality (methodology) (Guba 1990). The major aims of this study are to investigate the SCQRM practices adopted for dealing with quality risk issue, develop a holistic framework of SCQRM, and investigate its impact on the firm performance. The context of the current research is that of current risk management practices adopted by firms, meaning an appropriate ontology for the research is objectivism. The epistemology of this study can be viewed as knowledge of what represents good SCQRM practice, how to adopt SCQRM, and what are the best practices for applying them.

There are two main streams of methodologies: quantitative and qualitative. Their fundamental difference between the quantitative approach and qualitative approach lies on the epistemological and ontological issue. From an ontological point of view (view on reality), a quantitative approach concerns a single, objective and independent reality in which it can be known and can be described as it really is. In contrast, qualitative approach includes multiple social realities that cannot be described free from people's points of view and particular interests. From the epistemological point of view (view on knowledge), quantitative approach summarize the knowledge in the form of time, value and context free generalizations. In contrast, qualitative approach can only summarize the reality via human mind and via socially construct meanings (Sale *et al.* 2002, Slevitch 2011).

Therefore, selecting an appropriate methodology is extremely important as it is fundamental for conducting any successful research. The major aim of methodology is to enable the researcher to plan and examine the logic of the research method being used; to assess the performance of individual research techniques; and estimate the likelihood of the research design making a useful contribution to knowledge (Krippendorff 2004). Thus, the research becomes more understandable by having adopted a well defined research methodology, since methodology provides "a language for talking about research processes" (Eldabi *et al.* 2002, Krippendorff

2004). However, there is no perfect methodology as different research areas have different characteristics and concerns. Furthermore, each empirical research methodology has a specific way to collect and analyse data, and it also has its strengths and limitations (Amaratunga *et al.* 2002). For example, a quantitative paradigm can provide wide coverage over a range of situations. Also, the results from quantitative research can be of considerable relevance to policy decision making if the statistical analysis is aggregated from a large sample. However, the quantitative approach tends to be rather inflexible. On the other hand, the qualitative paradigm has a more natural data-gathering method. However, the research results derived from a qualitative approach may appear less credible to policy makers, and it is harder to control the pace, progress and end point of the research process (Easterby-Smith 1991, Amaratunga *et al.* 2002).

As SCQRM is a relatively new topic in SCM, a context-free generalizations related to SCQRM are more useful than a subjective perspective from practitioners who interpret their realities of SCQRM practices. Thus, a quantitative research approach is chosen as the research methodology in this study for investigating what exactly SCQRM is and its impact on the firm's performance. Moreover, an objectivism perspective of quantitative approach can reflect the reality and represent a generalizable result, so the quantitative approach is a more appropriate method to

provide a clear understanding of SCQRM.

Moreover, there are a number of reasons to support the appropriateness of adopting quantitative methodology in this research:

(i) In order to identify the current SCQRM practices used by firms, a large scale sample size is needed to validate the proposed SCQRM practices, and ensure the generality of the SCQRM practices.

(ii) The quantitative approach is more likely to focus on the facts, and thus the developed SCQRM measurement instruments can be examined according to an objective perspective. Also, by adopting a quantitative approach, the dimensionality of SCQRM can be investigated and measurement items can be regrouped into simpler elements (i.e. SCQRM dimensions).

(iii) By adopting a quantitative approach, hypotheses can be formulated and tested. Therefore, the performance effect of SCQRM can be scrutinized and analyzed by a number of statistical analysis techniques.

In short, by adopting a quantitative approach, the proposed SCQRM concepts can be operationalised, so that they can be measured. Researchers collect a large population of sample data from the practitioners in order to achieve valid and reliable results (Flynn *et al.* 1994).

The aim of this chapter is to describe the methodology that is adopted by this

research. It covers the details of the analysis technique, questionnaire design, and sampling that are employed in this study. A quantitative, survey-based methodology is adopted to analyse the primary data collected. Moreover, Confirmatory Factor Analysis (CFA) and Structural Equation Modeling (SEM) are the major tools used to analyse the primary data obtained from the questionnaire survey. The methodology of scale development and the mediating effect testing of the structural model are discussed in this chapter.

3.2 FACTOR ANALYSIS

Factor analysis is defined as an interdependent technique to determine the underlying structure among the variables in the analysis (Hair *et al.*, 2009). Two types of factor analysis are conducted in the study: Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) (Anderson and Gerbing, 1988). EFA always is the first undertaken before estimating the measurement model. The aim of EFA is to reveal whether the variables are grouped under the same factor as that proposed in the conceptualized model. Moreover, the major application of EFA is to search for structure among a set of variables, so EFA does not have a priori constraints while estimating how many factors are to be extracted (Hair *et al.*, 2009).

However, if the researcher has a preconceived idea of what the structure of

the data base of his proposed framework should be, whether based on theoretical considerations or on empirical support described in the literature, factor analysis is needed that can take a confirmatory approach to evaluate the degree to which the data fits the expected structure. i.e. CFA.

CFA is conducted for assessing the "fit" of the indicators representing the latent variables. There are five important elements in CFA: latent variable (LVi), measured variable (indicator X_i), the item loadings on specific constructs (λ), the relationship amount constructs (ϕ), and error of each indicator (*e*). Moreover, there are only correlational relationships in CFA, so the arrows are represented by a two-headed curved arrow. In CFA, there is no cross loading, so only the loading (i.e. λ) theoretically linking the measured variable to its corresponding latent variable is calculated (Hair *et al.*, 2009). Figure 3.1 illustrates a path diagram of a CFA model. The ellipse indicates the latent variable, and the rectangular box indicates the measured variable.

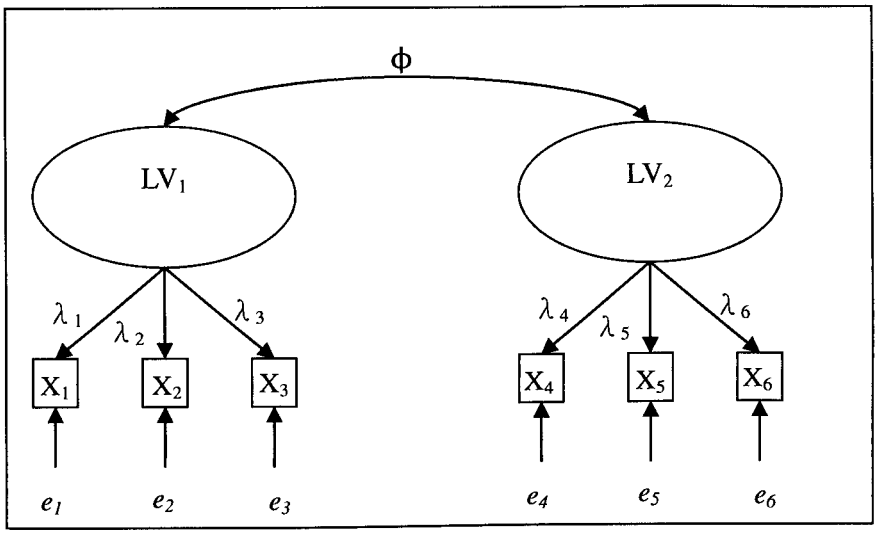

Figure 3.1 An illustration of a CFA model

The application of EFA and CFA in this research and their rules of thumb are further described in the scale development process in section 3.4

3.3 STRUCTURAL EQUATION MODELING

Structural Equation Modeling (SEM) is a methodology which is a confirmatory approach to the multivariate analysis of a structural theory (Byrne 1998). It is a useful tool in theory development because of two vital aspects in its procedures: (i) the process in the study are presented as a structural model that consists of a series of regression equations; (ii) a clearer conceptualization of the theory can be obtained as the structural relationships can be modeled as an illustration (Byrne 1998). Moreover, Hair *et al.* (2009) provided a clear description of three characteristics of the SEM model. The SEM model's characteristics include "(i) *the estimation of multiple and interrelated dependence relationships, (ii) an ability to represent unobserved concepts in these relationship and account for errors*

in the estimation, and (iii) defining the model to explain the entire set of relationships". In short, SEM is a statistical methodology that can enable the researchers to propose their hypotheses to construct the model and statistically test all hypotheses simultaneously in order to determine the consistency between the model and the data. Also, it is a superior multivariate technique that can improve statistical estimation by not overlooking measurement error.

SEM can assess (i) how closely the observed data correspond to the expected patterns, (ii) how well the relationships among the latent variables represented by the model are established, (iii) how amenable to accurate measurement is the population (Shah and Goldstein 2006). In this way, a desirable outcome in SEM analysis implies that the hypothesized model has provided a good approximation of real world phenomena by data sampling (Shah and Goldstein 2006). Also, the SEM technique supports a "specification search" when a desirable outcome cannot be obtained from the initial model. Thus, the researchers can change their model to improve its fit to the data (Long 1983, Shah and Goldstein 2006).

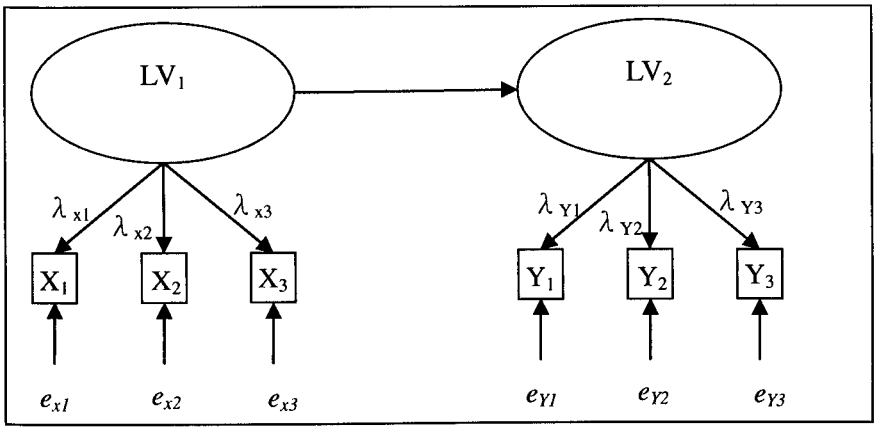

Figure 3.2 An illustration of a Structural model in SEM

In this research, the classic two-step testing SEM approach is adopted in which CFA can be viewed as the pre-step of the path analysis. CFA can provide evidence for the validity of individual measures based on the model fit and other evidence of construct validity (Hair *et al.* 2009). However, CFA is only limited to analysing the nature of relationships between constructs. A structural model should be examined after the validation of CFA is completed. Figure 3.2 shows an example of a structural model of SEM. The structural model in Figure 3.2 is similar to the CFA model in Figure 3.1. There are a few changes in the transition of a CFA model to a structural model (Hair *et al.* 2009). First, the structural model specifies the structural relationships between constructs, so the correlational relationship (which is represented as a two-headed curved arrow in CFA) is changed to a dependence relationship (which is represented as a single-headed arrow in the structural model). Second, the constructs in the structural model are classified identically. The independent latent variable is labeled as exogenous (LV_1) and the dependent latent

variable is labeled as endogenous (LV_2).The item measures in the endogenous latent variable need to be renamed from X_i to Y_i in the structural model as they need to show the distinction between the endogenous item measures and the exogenous item measures. Moreover, the error variances of the measurement items also need to be renamed to match the endogenous-exogenous distinction. In the transition from CFA to a structural model, the observed covariance model remains unchanged, and the differences of model fit are associated only with the different relationships represented in the structural model (Hair *et al.* 2009).

In addition to the description of the structural model, single-headed arrows represent structural regression coefficients and thus indicate the impact of one variable on another (Byrne 1998). For instance in Figure 3.2, the single-headed arrow points toward the LV_2 which implies that the factor LV_1 "causes" the factor LV_2. Similarly, the three single-headed arrows leading from LV_1 to each of the indicator variables (x_1, x_2, x_3) suggests that the regression coefficients (λ_1, λ_2, λ_3) are influenced by LV_1. Moreover, the regression coefficients (λ_1, λ_2, λ_3) represent the magnitude of expected change in the indicators (x_1, x_2, x_3) for every change in the related latent variables (LV_1).

In this decade, SEM methodology is one of the most popular empirical research approaches in OM and SCM areas. Shah and Goldstein (2006) stated that it

is one of the preferred data analysis methods among empirical operation management researchers and this is also reflected in the publication trend in the top grade operations management journals (such as Management Science, Journal of Operations Management, Decision Sciences, and Journal of Production and Operations Management Society).

Many empirical researchers advocate employing SEM as a more appropriate path analysis methodology to examine the links among OM practice and performance (Prahinski and Benton 2004, Yeung *et al.* 2005, Yeung 2008, Narayanan *et al.* 2011). For example, Yeung (2008) proposed a SEM model to provide a better understanding of relationships among strategic supply management, quality initiatives and firm performance. Narayanan *et al.* (2011) examined the effects of internal and external business integration processes of outsourcing strategies in their path model linking to firm performance, and further analysed its possible role as an antecedent to the outsourcing strategies. Ahire and Dreyfus (2000) conducted a SEM test to show the impact of design management and process management on internal and external quality performance. Moreover, Prahinski and Benton (2004) compared various types of supplier communication strategy path model that could influence supplier performance by proposing a number of SEM models.

Therefore, to examine the linkages among SCQRM practices and firm

performance, SEM is employed in this study. However, SEM is usually not recommended for exploratory research when the measurement structure is not yet defined, or the theory that underlies patterns of relationships among latent variables is not yet well established (Shah and Goldstein 2006). Thus, a scale development process is conducted, so the measurement structure and the underlying pattern of the SCQRM construct is investigated before the performance of SCQRM is studied.

3.4 SCALE DEVELOPMENT

In multi-item measurement and scale development, there are two major challenges: (i) to reduce measurement error by providing a more robust representation of complex variables (Menor and Roth 2007, Drolet and Morrison 2001); (ii) to select the appropriate measurement items (Little *et al.* 1999, Menor and Roth 2007), that cover the construct domain with the desired reliability and validity. For dealing with these challenges, this research adopts the scale development approach by Menor and Roth (2007) as the skeleton, and combines this with steps suggested in the literature (Churchill 1979, DeVellis 2003, Hinkin 1995, Janz and Prasarnphanich 2003, Kaynak and Hartley 2006, Netemeyer *et al.* 2003, Rungtusanatham *et al.* 1999, Schwab 1980), and forms systematic procedures to develop and validate the measurement of SCQRM.

Figure 3.3 shows the flow of scale development.

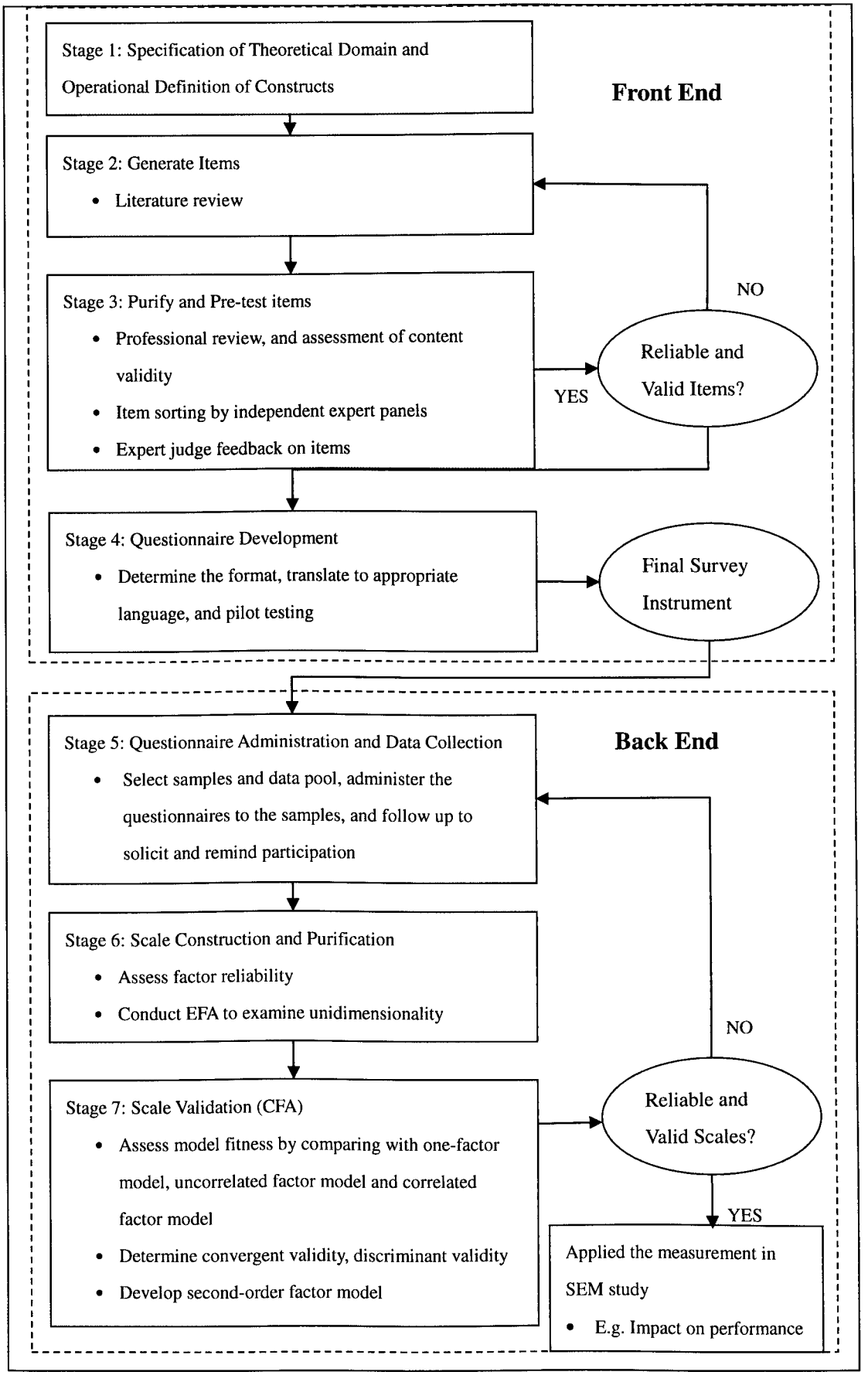

Figure 3.3 Seven-stage approach for new measurement development

3.4.1 Specification of Theoretical Domain and Operational Definition of Constructs (Stage 1)

The conceptualizations should be based on a thorough literature review (Netemeyer *et al.* 2003). The researcher needs to clarify the characteristics which are included in the definition. This conceptualization step provides the conceptual model in which item measurement and scale development take place.

3.4.2 Item Generation (Stage 2)

While the purpose of developing a scale has been clearly articulated, the measurement developer should start to generate an item pool (DeVellis 2003). The new multi-item measurement scales are supposed to reflect that SCQRM practices. Moreover, the measurement instruments are derived from measurement items either cited in, or motivated by existing literature (Churchill 1979). Moreover, the literature suggests that the items generated must not be either too narrow nor too broad (Netemeyer *et al.* 2003). At this stage, the conceptual domain as specified will be captured (Churchill 1979), and scale items will be generated to tap into the conceptual domain (Hinkin 1995, Netemeyer *et al.* 2003). Moreover, while creating the new items, the sources of potential confusion, such as "multiple negative", "double barreled", "ambiguous pronoun reference" should be carefully avoided (Hinkin 1995, Netemeyer *et al.* 2003).

3.4.3 Purify and Pre-test Items (Stage 3)

The most basic requirement of good item measures is content validity (Li *et al.* 2005). This means the measurement items in an instrument cover the major content of the construct (Li *et al.* 2005, Churchill 1979). In other words, the good content items should represent the intended domain of the concept that is going to be measured. Rungtusanatham (1998) mentioned that "*content validity can be achieved, while the generated items can constitute a randomly chosen subset of the universe of items that represent the entire domain of the construct*". Moreover, Li *et al.* (2005) stated that content validity should be achieved through a comprehensive review of relative literature and through interviews with practitioners and academics. In this study, the review of literature is complemented by in-depth discussions with practitioners who are familiar with SCQRM practices in their manufacturing firms.

In this study, a content validity test should be conducted in order to ensure that the empirical scrutiny is sufficiently rigorous and adequate for the measurement items and construct definition. Moreover, the two-step content validity test will be conducted as proposed by Rungtusanatham (1998, 1999). The content validity test is an item-sorting exercise which consists of two steps: (i) inter-judge agreement percentage and (ii) application of Cohen's kappa (κ) test.

At first a panel of expert judges with three OM academics and two

industrialists (directors of manufacturing firms in Hong Kong and the PRD region in China) possessing the appropriate knowledge, skills and experience in SCQRM are selected for the test. The instrument used for item sorting consists of a definition of each of the four SCQRM dimensions, and a randomized list of all measurement items (Menor and Roth 2007, Hinkin 1995). The results of the sorting exercise are analyzed by obtaining the Cohen's kappa (κ), which is an index of beyond–chance agreement among different judges for the overall task and σ_κ to assess the content validity (Cohen 1960, Rungtusanatham 1998). The Cohen's kappa (κ) can be found from:

$$\kappa = \frac{F_a - F_c}{N - F_c} \tag{3.1}$$

where F_a is the number of items classified into the same SCQRM dimensions by all J judges, summed over all dimensions i for i = {1,...,D},

$$F_a = \sum_{i=1}^{C} F_{i(a)} \tag{3.2}$$

$F_{i(a)}$ is the number of measurement items classified into the same category by all J judges

F_c is the number of measurement items for which agreement, as to their classifications, among all J judges is expected by chance, summed over all categories i *for* $i = \{1,...,C\}$.

$$F_c = \sum_{i=1}^{C} F_{i(c)} \tag{3.3}$$

with

$$F_{i(c)} = N\left(\prod_{j=1}^{J} \frac{F_{ij}}{N}\right) \tag{3.4}$$

F_{ij} is the number of measurement items classified into *ith* category by the *jth* judges; N is the number of independent measurement items

Cohen's kappa (κ) index ranges between +1.00 and –1.00, where kappa > 0.00 means that the observed agreement among judges is a beyond chance agreement; on the other hand, while kappa value tends to +1.00, it indicates a perfect inter-judge agreement (Rungtusanatham 1998).

After obtaining the Cohen's kappa (κ), the inter-judge agreement percentage is obtained. The inter-judge agreement percentage is the percentage of judges assigning the item to the desired category (Hardesty and Bearden 2004). According to the study of Hardesty and Bearden (2004), the cut-off ranging from 60% to 75% is treated as a minimum extent of agreement among judges for item retention.

3.4.4 Questionnaire Development (Stage 4)

While designing a questionnaire, there is a couple more points that need to be taken into consideration. Hinkin (1995) suggested that the researchers need to consider the following issues: (i) the number of items in the construct, (ii) the selection of a Likert scale, (iii) negative wordings.

Since the target respondents are senior managers in China and Hong Kong, the questionnaire needs to be translated from English into Chinese. In this study, a forward and backward translation process of the questionnaire should be used when translating the questionnaire items into the appropriate language for the informants (Brislin 1980). After the completion of the design of the questionnaire, the questionnaire is given to the practitioners (the information of the practitioners are listed in Appendix 2) to have a pilot test for fine-tuning the wording. Also, feedback on the questionnaire design can be obtained from the pilot test. The major purpose is to ensure the practitioners have a clear understanding of respondents of the measurement items.

3.4.5 Questionnaire Administration, Data Collection (Stage 5)

In this stage, a questionnaire was sent to organizations' senior management in the selected data pool. The questionnaire, including a covering letter, was sent via email. Endorsement letters was included, too, from the *Institute of Purchasing and*

Supply Hong Kong (IPSHK) and *The Institute for Supply Management, Pearl River Delta (ISM-PRD)* are attached in the email (Both letters are attached in Appendix 6). Three weeks after, a reminder will be sent by email to all potential respondents. Moreover, phone calls will be made to ask for their participation after the sending of the reminder mails. Data purification will proceed once the data collection is finished. The purification steps include (i) estimating a comparison between the "first wave and second wave" , and (ii) dealing with missing values.

3.4.6 Scale Construction and Purification using EFA (Stage 6)

In this stage, EFA is used for purifying the scale. Narasimham and Jayaram (1998)'s two-step approach is employed: conducting EFA is to assess the unidimensionality, then Cronbach's alpha to assess the reliability, and to purify the scales (Zhao *et al.* 2008, O'Leary-Kelly and Vokurka 1998). In addition, Devellis (2003) suggests that items which are correlated negatively or weakly with other items in the same construct be removed. The rule of thumb of removal is 0.20 (Netemeyer *et al.* 2003, Robinson 1991).

EFA is usually used (with a reducing factor) in principal components analysis to determine the main constructs measured by the items (Zhao *et al.* 2008). The major indications that need to be confirmed during EFA are: (i) All the factor loading in EFA is assumed to be greater than the minimum value of 0.30 (Chen and Paulraj

2004a). (ii) Convergent validity of the construct is acceptable if the eigen value exceeds 1.0 (Hair *et al.* 2009, Chen and Paulraj 2004a) (iii) The percentage of variance of the measurement items extracted by the construct should be larger than 0.50 (Hair *et al.* 2009). This indicates that more than half of the variance of the items is accounted for by the construct. Moreover, the cut-off point of Cronbach's alpha is greater than 0.70 (Nunnally 1978). It is used as the indicator of the strength of the item, and the adequacy of the reliability of the subscale.

3.4.7 Scale Validation using CFA (Stage 7)

In stage 7, the validation of the SCQRM model is tested by using CFA. The results of the CFA test enable us to compare the theory developed against the reality that is presented in the data (Hair *et al.* 2009). Construct validity is defined as "*a set of measured items that actually reflects the theoretical latent construct those items are designed to measure*"(Hair *et al.* 2009). Thus, construct validity deals with the accuracy of the measurement and provides the evidence that the items measured, taken from the sample, represent the actual score in the population. In this research, the validity of the scale is assessed in three ways, by: (i) the model fit, (ii) convergent validity and (iii) discriminant validity.

3.4.7.1 Overall Fit

The model fit is assessed by using absolute, incremental and parsimonious measures to provide different aspects in showing "how well the estimated relationships in the model match the observed data" (Shah and Ward 2007). Three types of measures are usually reported to show the overall model, and the recommended values of these indices for the acceptable model fit are shown in Table 3.1. The absolute measures indicate how well the specified model reproduces the observed data; incremental fit measures show how well the proposed model fit the baseline model, such as null model (assuming that all the observed variables are uncorrelated); parsimony fit measures assess the parsimony of the proposed model and provide information about the fit of the model versus the estimated coefficient needed to achieve the level of fit. Also, the parsimony fit is related to the model complexity (Shah and Ward 2007, Hair *et al.* 2009, Shah and Goldstein 2006).

Table 3.1 Recommended values for acceptable model fit (adopted from Shah and Goldstein,2006; Shah and Ward, 2007)

Measures of fit	Statistics measures	Recommended values for acceptable model fit
Absolute	χ^2-Test statistic (d.f.)	NA
	Root mean square error of approximation (RMSEA)	≤0.08
	RMSEA, 90% confidence interval	(0.00;0.08)
	Standardized root mean square residual (SRMR)	≤0.10
Incremental	Non-normed fit index (NNFI)	≥0.90
	Normed Fit Index (NFI)	≥0.90
	Comparative fit index (CFI)	≥0.90
Parsimonious	Normed χ^2 (χ^2/d.f.)	≤3.0
	Parsimony normed fit index (PNFI)	≥0.70

3.4.7.2 Convergent Validity

Convergent validity is the "extent to which indicators of a specific construct converge or share a high proportion of variance in common" (Hair *et al.* 2009). In other words, if the construct has a good convergent validity, the item measurement should correlate closely with other measures designed to measure the same construct (Churchill 1979). In this research, three approaches are adopted to assess the convergent validity among item measures: (i) factor loading; (ii) average variance extracted (AVE) and (iii) convergent reliability.

For achieving a high degree of convergent validity, a high factor loading is

one of the important considerations. Hair *et al.* (2009) suggested that the rule of thumb is that standard loading should be 0.5 or higher. Another indication of convergent validity is AVE. AVE is treated as a summary indicator of convergence in that it is calculated as the mean variance extracted for the measurement items loading on a construct. An AVE value of 0.5 or higher is at the threshold of suggesting adequate convergence. Finally, the composite reliability is taken as the measure of convergent validity in which the rule of thumb is that, for good reliability, it should be higher than 0.7.

3.4.7.3 Discriminant Validity

According to Hair *et al.* (2009), discriminant validity is "*the extent to which a construct is truly distinct from other constructs*". For achieving a high discriminant validity, both "how much the construct correlates with other constructs in the model" and "how distinctly the measurement items only represent this single construct" need to be indicated. There are several approaches to assess discriminant validity. In this research, the rigorous approach suggested by Hair *et al.* (2009) is adopted. The AVE values of any two constructs are compared with the square of the correlation estimated by two constructs. In order to prove a high discriminant validity in the model, the estimated AVE should be greater than the squared correlation estimated. This indicates that the latent construct explains more of the variance in its item

measures than the variance shared with any other construct.

3.4.7.4 Second-order Factor Model

A second-order factor model is a structural model that contains two layers of latent factors. It can be taken as explicitly representing the constructs that impact on the first order factors. Byrne (1998) stated that *"the second-order factor was hypothesized as accounting for, or explaining all of the covariances among the first-order factor"*. Also, the second-order factor does not have its own set of measurement indicators (Byrne 1998). The first order factors act as indicators of the second-order factor (Hair *et al.* 2009). Figure 3.4 contains an example of a second order model. As shown in the diagram, the three first-order factors are dependent variables since they are presumed to be explained by the second order factor. Also, the second order factor is the only independent variable (Byrne 1998).

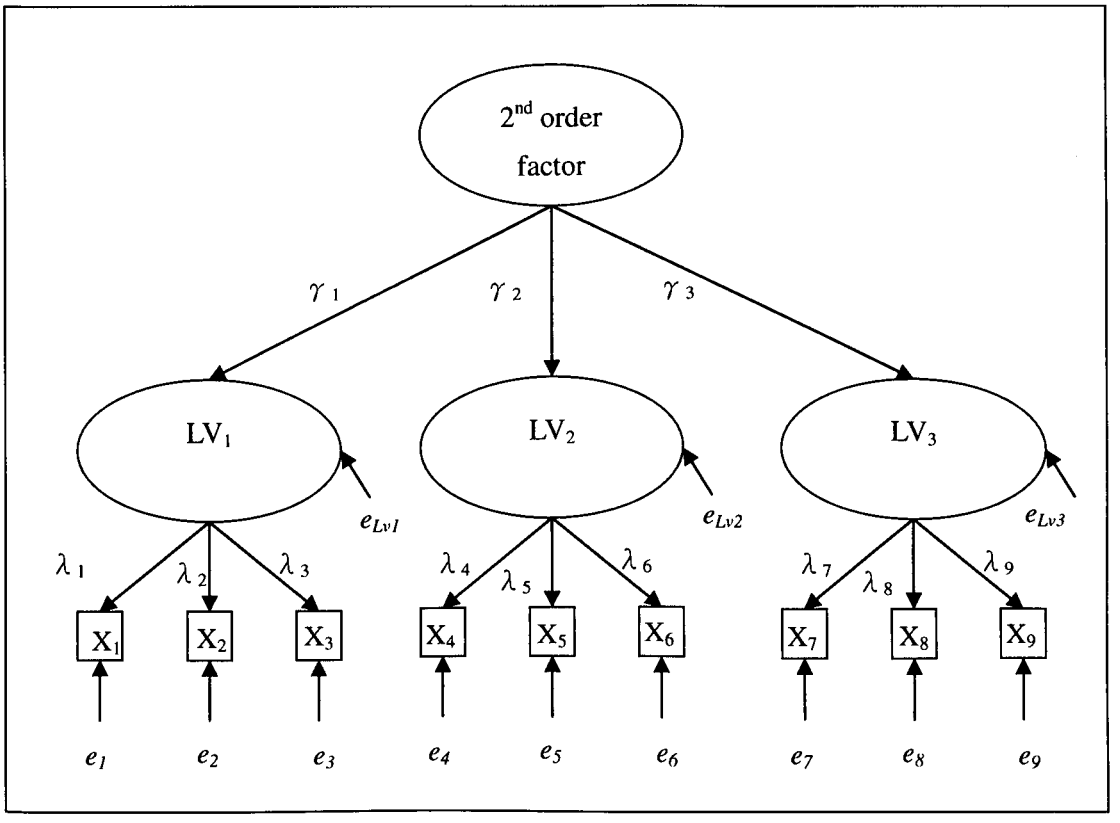

Figure 3.4 An illustration of a second-order factor model

Moreover, the regression coefficients (γ_1, γ_2, γ_3) represent the magnitude of expected change in the first order factors (LV_1, LV_2, LV_3) for every change in the second order factor. In addition, a minimum of three first-order factors is required in order to evaluate the second-order factor model.

In scale development, the assessment of a second-order factor model is always the last step of scale development (Kaynak and Hartley 2006). According to Hair *et al.* (2009), the testing of the second-order model should be done in conjunction with the more theoretical and pragmatic concerns. Hence, the second-order model should be assessed rigorously for nomological validity which is concerned with whether the relationships between the constructs in the measurement

model make sense. Thus, to pass the nomological validity test, all the structural links in the second-order model need be positive and significant. In addition, a more robust nomological validity test can be conducted by showing that a second-order model has a greater monological validity than a first-order model.

3.5 TESTING THE MEDIATING EFFECT

For testing mediation models, SEM has been suggested as the best tool to examine the mediating relationship because of the flexibility its SEM programs afford in model specification and estimation options (Preacher and Hayes 2008). For testing mediation effect in an SEM model, the procedures proposed by Sarkis *et al.* (2010) are followed. In traditional methodology, mediation is tested by using a simple regression approach. However, regression may produce an inaccurate mediator score as it does not consider the measurement error problem. Hopwood (2007) stated that the measurement error problem could cause difficulties in modeling causation, or possibly even result in reverse causation. Applying SEM as the basis on which to test for mediation problems can avoid this problem, as SEM has included the measurement error of the whole model.

In Sarkis *et al.* (2010)'s procedure, four conditions need to be satisfied in the relationships amongst the variables to indicate the existence of a mediating effect: (i)

before including the mediator, dependent variables need be influenced by the independent variables (i.e. a^1 needs to be significant); (ii) the mediator needs to be influenced by an independent variable (i.e. b needs to be significant); (iii) the dependent variable must be influenced by the mediator (i.e. c needs to be significant); (iv) the effect of the independent variable on the dependent variable must reduce after adding the effects of the mediator (i.e. $a^2<a^1$). Figure 3.5 shows an illustration which explains the mediating effect model.

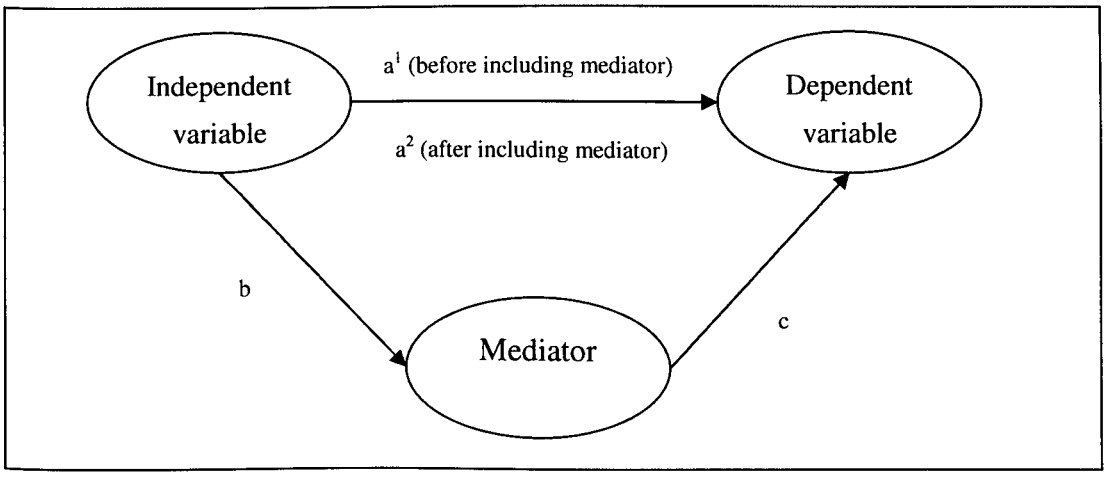

Figure 3.5 An illustration of the mediating effect model

There are three possible results of testing the mediating effect. First, the independent variable is claimed as completely/fully mediated by the mediator if conditions (i) to (iv) are satisfied and a^2 becomes significant. Second, conditions (i) to (iv) are satisfied, however, a^2 remains insignificant. Then, the effect of the mediator is that the independent variable is claimed to have been 'partially' mediated. Finally, if none of the conditions are satisfied, there is no mediation (Sarkis *et al.* 2010).

3.6 CHAPTER SUMMARY

This chapter has provided the details of the research methodology used in this study, and of the designs applied in the research. The quantitative research approaches used to develop the measurement instruments and analyse the conception framework by the collected data are discussed in detail.

There are two statistics software packages applied in this research. SPSS v17 is used as a tool for conducting EFA, the reliability test, and for testing the correlation of each item. Lisrel 8.54 is used as the major software package in more advanced quantitative analysis, including CFA and SEM. SEM is the core methodology used for analysing the primary data obtained from the questionnaire survey sent to manufacturing firms in the Pearl-river-delta region in China.

The methodology of scale development is also mentioned in this chapter. A 7-stage procedure is used for conducting a robust scale development process for ensuring the proposed items are reliable and valid. Moreover, the questionnaire is assessed by an expert panel for content validity, accurate translation, and feedback and comments on the final items before the questionnaire is finalized.

Moreover, the proposed models in this study are tested by the SEM technique which statistically tests all hypotheses in the model simultaneously in order to determine the consistency between the model and the data. Also, SEM is a superior

methodology that estimates the correlation of the structure link by not overlooking measurement error.

In summary, the methodology of scale development (section 3.4) adopted in scale development of SCQRM is presented in Chapter 5. The SEM testing approach stated in section 3.5 is adopted in assessing the SCQRM-performance model in Chapter 6. In addition, the approach to testing the mediation effect (section 3.5) which is used to test the mediating effect of quality performance in SCQRM-performance is also presented in Chapter 6. However, the conceptual development of the theoretically important constructs needs be defined before the scale development procedures begin (Churchill 1979, Menor and Roth 2007, Hinkin 1995). Therefore, the theoretical development of SCQRM is presented in Chapter 4.

CHAPTER 4. CONCEPTUALISATION AND OPERATIONALISATION OF SUPPLY CHAIN QUALITY RISK MANAGEMENT PRACTICES

4.1 INTRODUCTION

Although product recall cases have been viewed as a technical/engineering issue related to quality and safety in the public domain, some scholars have adopted theories in Operations Management (OM) to view this issue in a new and fresh perspective (Marucheck *et al.* 2011). For example, Lewis (2003) adopted an integrated theory of OM and Risk Management (RM) to solve operational risk which indicates the potential threats which lead to undesired consequences for stakeholders. In his study, he stated that effective risk control is more similar to quality management than to process control, and is considered as a multi-dimensional concept, consisting of prevention, mitigation and recovery. Tang (2008) proposed his 3R approach to managing product recall incidents as he thinks that continuous improvement is the basis for supporting its three dimensions: readiness, responsiveness, and recovery. He linked the three key dimensions with "actionable items" in production, logistics, product development and communication, to lighten the risk associated with product recall.

In previous literature and documents, these definitions and explanations

clearly indicate that SCRM is a very broad and multi-dimensional concept, involving several diverse aspects of an organization. For example, Lewis (2003) focused on process control of *internal operation* that might lead to negative consequences for stakeholders; Tang (2008) proposed the three major elements of continuous improvement in dealing with SCQR that occurs in the *downstream* network and with enhancement of the effectiveness of product recall management; Jüttner *et al.*(2003) proposed some possible *strategic directions* in supply chain management and in procurement management so as to minimize the overall supply chain uncertainty.

As mentioned in Chapter 2, managing SCQR involves many diverse issues. This study focuses on identifying the determinants of SCQRM in an organization's supply chain (i.e. supply-chain related issues). In general, SCQRM enables an organization to react more quickly and effectively to negative outcomes and other uncertainties/threats of SCQR in a supply network, thereby allowing the firm to establish a superior competitive position. In addition, firms well prepared with a SCQRM plan are more sensitive to risk, better capable of noting unpredicted and undesired incidents from the supply chain, and are able to respond promptly. Given that an organization equipped with SCQRM can directly react to quality uncertainty in the supply network and can promptly deliver good quality and safe products to their customers. Therefore, an organization's SCQRM is a vital factor which affects

its overall global competitiveness.

While the benefits of SCQRM are generally acknowledged, not many research studies exist which address how an organization can reduce the quality risk inherent in the upstream supply chain. Only limited research has been conducted empirically or analytically to explore the SCRM practices to deal with SCQR. This research addresses this gap by undertaking an empirically driven study to identify and develop critical SCRM practice that influences an organization's performance. In order to achieve this goal, a conceptual framework of SCQRM is developed

In the following sections, the theoretical development of the SCQRM framework and the constructs are described. Then, the proposed measurement items that represent these constructs are presented.

4.2 SUPPLY CHAIN QUALITY RISK MANAGEMENT PRACTICE

SCQRM in this research is defined as the set of concrete actions undertaken by an organization to promote effective SCQRM practices for mitigating quality risk in its global supply chain. The aim of these practices is to manage quality problems from the sourced materials which may cause problems and catastrophic harm to products.

After reviewing and consolidating the literature, four distinctive dimensions

of SCQRM practice are proposed: risk shifting, risk sharing, risk avoidance and risk remedy. The four constructs cover upstream (*risk avoidance*), and downstream (*risk remedy*) sides of a supply chain, and strategic risk allocation process (*risk shifting* and *risk sharing*). Other factors, such as imitation, flexibility, control (Miller 1992, Jutter *et al.* 2003), loss reimbursement and distribution (Covello and Mumpower 1985), resilience (Waters 2007), are also identified in the literature. Although these factors are of great interest to researchers, they are not all included since some of them are only useful in managing supply chain disruption risk. In fact, some of them are included in these four dimensions (e.g. risk control is a kind of avoidance practice, and loss reimbursement and distribution is related to risk allocation in shifting and sharing). Table 4.1 shows the literature from which the four SCQRM practices are consolidated while reducing SCQR.

Table 4.1 Four SCRM dimensions

SCQRM	**Description**	**Literature**
Risk Shifting (RSF)	The major aim of RSF is to transfer the undesired negative consequences of SCQR, such as the economic loss, to the business partners. It is a strategic practice that is often paired with RSR practice in risk allocation.	Baiman *et al.*(2000), Yang *et al.* (2009) , Balachandran and Radhakrishnan (2005), Camuffo *et al.* (2007)
Risk Sharing (RSR)	RSR extends the cooperation activities to sharing the risk and negative consequences. With adoption of this practice, the buyer and supplier firms	Camuffo *et al.* (2007) Zsidisin and Smith (2005) Zhu *et al.* (2007) Zirpoli and Caputo,

	cooperate to reduce the risk by improving product quality together. Buyer firms may need to allocate resources, including training and facilities to supplier firms in order to enhance the quality of the products.	(2002) Marucheck *et al.* (2011)
Risk Avoidance (RVO)	RVO occurs when management considers that the risk associated with supplier activities may cause quality uncertainties in materials. RVO contains several activities which involve supplier evaluation, multi-sourcing tactics, identifying and evaluating risks in the supply network, and the incoming inspection strategy. The major aim of these actions is to prevent the defective products from reaching the buyer firms.	Yeung (2008) Shin *et al.*(2000) Hwang *et al.* (2006) Zsidisin and Smith (2005) Balachandran and Radhakrishnan (2005) Lewis (2003)
Risk Remedy (RRY)	RRY is the remedial action that should be taken when product defects are found in the delivered products. It attempts to control and lessen the negative impact of SCQR.	Dawar and Pillutla (2000) Heerde *et al.* (2007) Zhao *et al.* (2009) Tang (2008)

These SCQRM practices can be viewed as two set of activities. Risk shifting and risk sharing can be viewed as risk allocation strategies. Risk allocation refers to the assignment of risk and its consequences that are being handled by the firm (buyer) side or supplier (seller) side. In addition, risk shifting and risk sharing are already defined as options for diverse risk allocation strategies in a relational context (Camuffo *et al.* 2007). The main aim of risk allocation is to balance the SCQR in the

supply network. It is important to balance the risk at the network level which is a basic element for establishing an optimal risk management strategy (Hallikas *et al.* 2004). They also claimed that a risk management strategy is associated with the supply chain relationships which often included transfer risk from one to another. Moreover, under risk allocation, SCQR can be successfully reduced since the more capable firm takes the risk instead of another firm which would need to invest more of its scarce resources to cope with the risk.

Another set of risk activities defined in this chapter is the "prevent–react" practice. The aim of preventive action is to avoid the risk and reduce the probability of SCQR happening. Reactive action focuses on the response action after SCQR has actually happened and attempts to mitigate its impact (Thun and Hoenig 2011). This pair of actions can also be viewed as a pair of *ex ante / ex post practices*. *Ex ante* and *ex post* are Latin words that are often used in management research. The meanings of *ex ante* and *ex post* are "*before the event*" and "*after the event*" respectively. For example, Lewis (2003) mentioned "*ex ante*" activities which encompass inspection activities to control risk from manufacturing defects. In this study, risk avoidance involves the preventive action to stop receiving unqualified/unsafe materials, thus it is an *ex ante* practice. Besides, the risk remedy approach is adopted while the defective products are revealed in the downstream supply chain, so it is an *ex post*

practice.

Figure 4.1 to Figure 4.4 show the right timing of these SCQRM practices applied in a supply chain. The figures illustrate the SCQRM activities being employed, and indicate the major party which is responsible for mitigating the SCQR (indicated in grey colour).

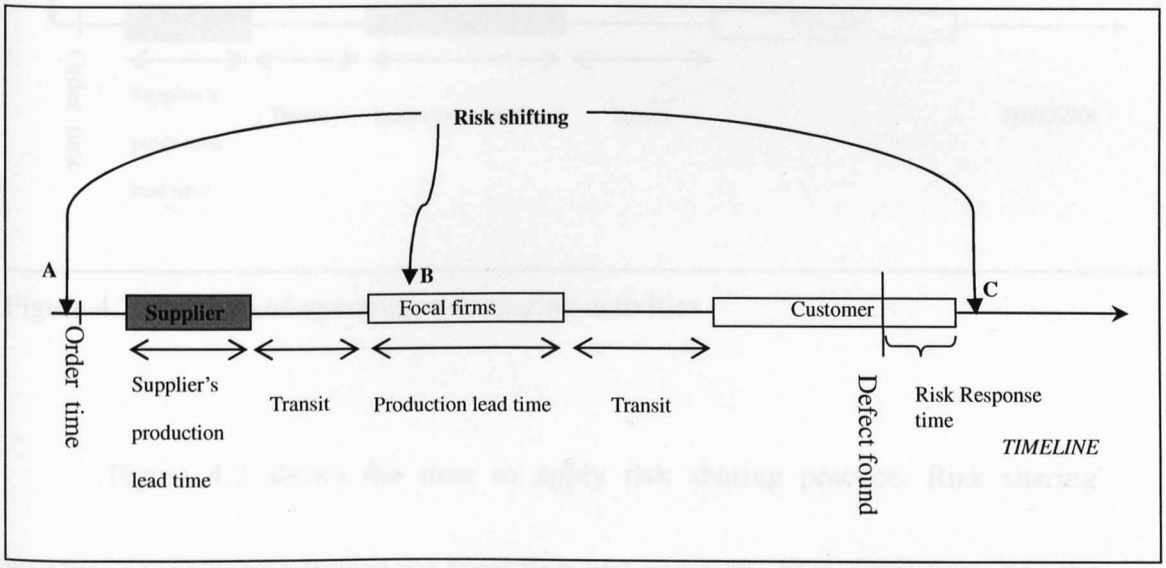

Figure 4.1 Timeline of operating risk shifting activities

Risk shifting includes setting up the penalty clause in the contract, so it starts before the purchasing order is placed (i.e. point A). At point B, the focal firm finds defects from the supplied components, so the supplier is penalised for the cost of replacement or rework. Moreover, while the customer reports a product defect of the focal firm and the defect originates from the supplier's component, the supplier may need to bear the responsibility for the economic loss of the focal firm. Therefore, the supplier may be also penalised by the focal firm at point C. In addition, risk shifting

has pushed the responsibility of quality assurance onto the supplier. Thus, the supplier is the only party to reduce the SCQR in the supply chain.

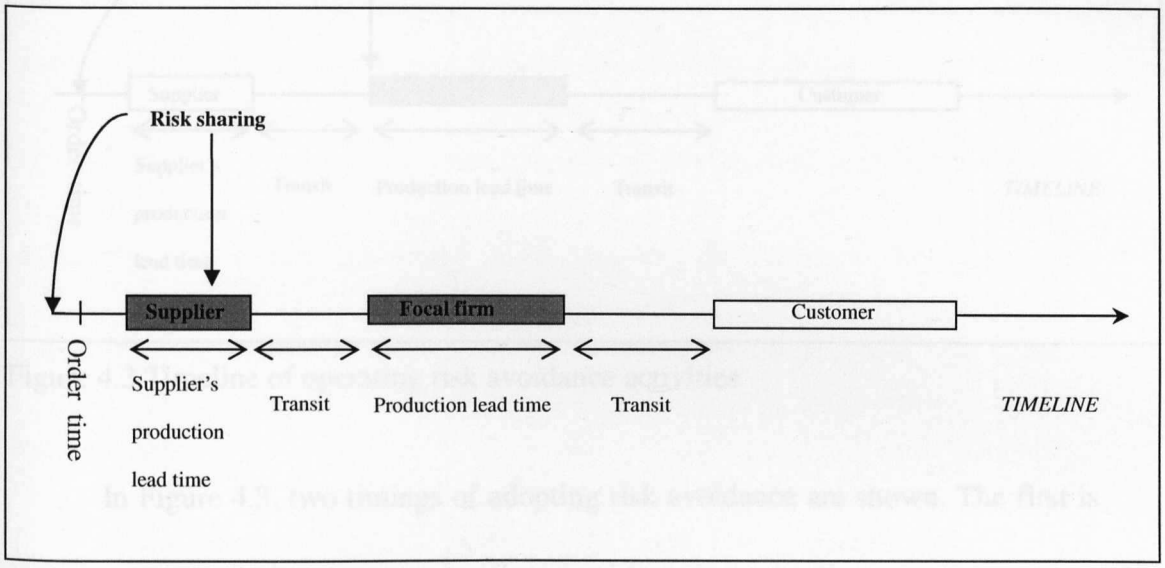

Figure 4.2 Timeline of operating risk sharing activities

Figure 4.2 shows the time to apply risk sharing practice. Risk sharing involves cooperation between the focal firm and suppliers. Also, focal firms and the supplier set up the supplier's manufacturing procedures together. Thus, risk sharing must start before the ordering time. Moreover, potential SCQR is monitored during supplier production on a regular basis. Since risk sharing is a cooperative activity, both focal firm and supplier parties are responsible for reducing SCQR.

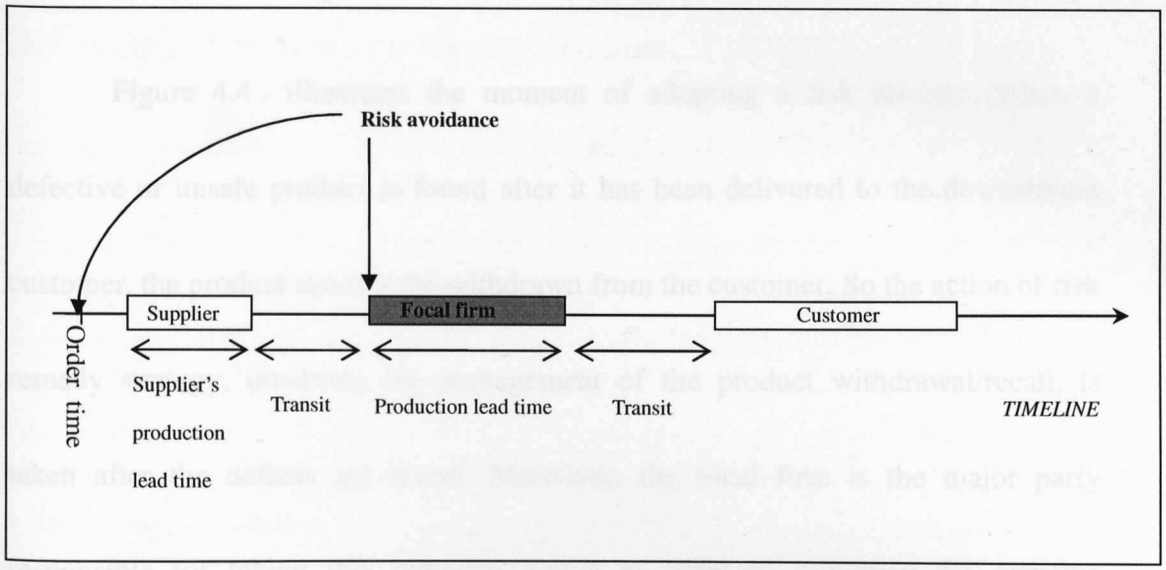

Figure 4.3 Timeline of operating risk avoidance activities

In Figure 4.3, two timings of adopting risk avoidance are shown. The first is related to supplier selection, so it must be before the order is placed. Also, risk avoidance consists of inspection activities which can take place while the materials are being received. Risk avoidance is a risk mitigation strategy that prevents defective or unsafe materials from entering the firm. This focal firm is the only party that is responsible for reducing SCQR.

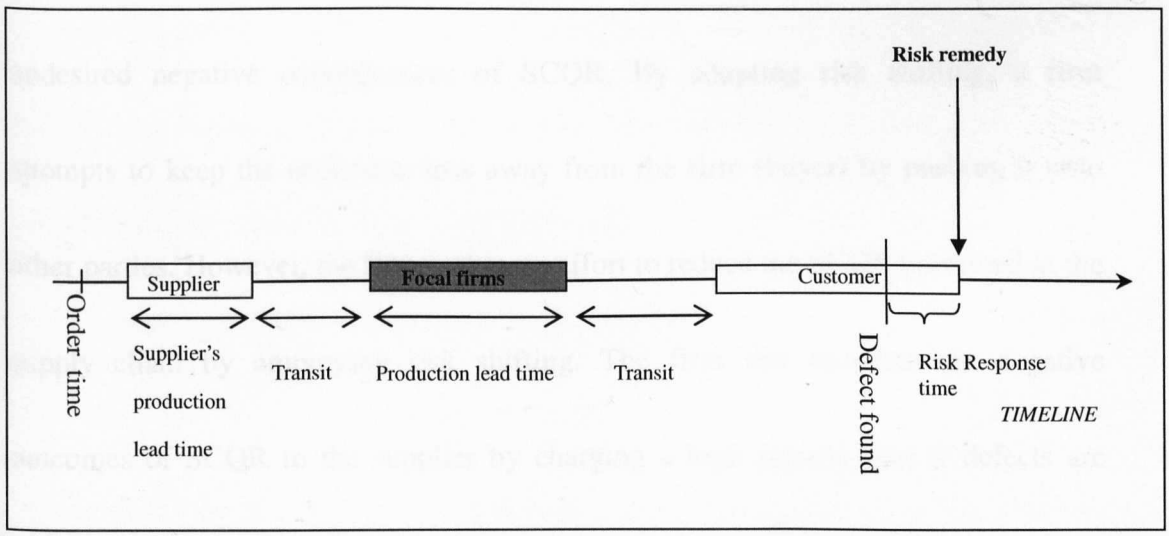

Figure 4.4 Timeline of operating risk remedy activities

Figure 4.4 illustrates the moment of adopting a risk remedy. When a defective or unsafe product is found after it has been delivered to the downstream customer, the product needs to be withdrawn from the customer. So the action of risk remedy strategy, involving the management of the product withdrawal/recall, is taken after the defects are found. Moreover, the focal firm is the major party responsible for taking this remedial action in order to minimize the negative consequences.

In the following sections, an operational definition of each SCQRM practice is provided and the initial set of representative items related to each construct is shown in Table 4.2-Table 4.5.

4.3 RISK SHIFTING

Risk shifting is the practice to protect the self-interest of the firm from the undesired negative consequences of SCQR. By adopting risk shifting, a firm attempts to keep the economic loss away from the firm (buyer) by pushing it onto other parties. However, the firm makes no effort to reduce the SCQR presented in the supply chain by employing risk shifting. The firm just transfers the negative outcomes of SCQR to the supplier by charging a high penalty cost if defects are found in the incoming inspection. The penalty is used to cover the internal failure

cost which is related to the loss for correction action, including the extra operation to rework the defective parts or order replacement components from another supplier.

However, the firm's inspection process may not guard against all the defective materials and some of them might be incorporated into the finished product and delivered to the customer. Thus, risk shifting can extend to transferring the external failure cost (i.e. cost related to product repair or unconditional replacement) to the supplier if the defect is related to the supplier's component. In this case, the firm can charge the supplier an extra penalty cost in order to reduce the warranty cost of product repair and replacement (Baiman *et al.* 2000). Thus, the firm's manager should consider the risk management costs of a product being contaminated and counterfeited when designing the sourcing model (Grackin 2008).

In addition, the supplier needs to pay extra attention to ensuring the product quality in order to avoid the heavy penalty from the buyer firm. Thus, the buyer firm can allocate fewer resources to the incoming inspection (Starbird 2001). Therefore, risk shifting is not only a practice to transfer the economic loss but also a strategy to push the quality assurance effort onto the supplier.

According to agency theory, SCQR happens when there are conflicting goals between principle (buyer) and agent (supplier) (Zsidisin and Ellram 2003). For example, the buyer wants to have a high quality product, but the supplier just

attempts to achieve a high profit margin. In other words, the supplier may not have the same objective as the buyer in ensuring the purchased product is perfect. Moreover, the effort of the supplier in quality assurance cannot be perfectly observed by the buyer. Looked at from the agency theory perspective (Eisenhardt 1989, Zsidisin and Ellram 2003), risk shifting is an outcome-based practice which aims to change the goal of the supplier and make it closer to the buyer's objective. This can be achieved by increasing the penalty for defective products. Eisenhardt (1989) mentioned that the outcome-based contract could effectively curb a supplier's opportunistic behaviour. Hence, the supplier will have a greater concern for the quality of the products and will be less inclined to attempt to indulge in opportunistic behaviour if the supplier needs to avoid a high penalty. Buyer and seller can both benefit from the risk shifting practice, as the buyer can achieve high quality products and the seller can get the full amount of payment with fewer penalties. In other words, the conflicts of self-interest between principal (buyer) and agent (supplier) are reduced. Moreover, risk shifting is an appropriate strategy when the uncertainty factor is insignificant. Outcome-based practice is not suggested for handling the risk while there is uncontrollable variance in the outcome (Eisenhardt 1989). Thus, risk shifting may not be capable to cope with the SCQR if the supply chain uncertainty is significant and uncontrollable. For example, if there is some technical uncertainty in

testing the product, how can the firm correctly penalize the supplier? If the number of supplier's supply chain layers is uncertain and the identity of sub-tier suppliers is completely unknown, how can a buyer firm fix an appropriate penalty? Buyer firms need to put more resources into ensuring that the risk shifting can effectively transfer the loss. Thus, Eisenhardt (1989) claimed that it becomes increasingly expensive to shift risk when uncertainty increases.

Another possible way of risk shifting is by transferring the economic loss by having product liability insurance (Ritchie and Brindley 2007, Berenson 1972b). The aim of the product liability insurance is to protect the business from claims for incidents related to the production and sale of products to the public. It can cover the liability of the firm for losses or injuries to the consumer, whether the quality problem is caused by manufacturing flaws or design defects. Though transferring the risk by having product liability insurance is costly, the amount of loss coverage mainly depends on market size.

Based on these characteristics of integrated risk shifting practices, a firm's risk shifting effort is measured through the following items: the tendency of shifting the responsibility of quality assurance to the supplier (RSF1 and RSF2), the action of penalizing the supplier for defects to cover the internal and external failure cost (RSF3, RSF4 and RSF5), and the use of product liability insurance (RSF6 and

RSF7). Table 4.2 lists the measurement items in the risk shifting construct.

Table 4.2 Measurement items in risk shifting

Item	Measurement items	Reference
RSF1	We think that the supplier should take most of the responsibility for quality problems that are caused by the supplier, and/or even from the supplier's suppliers.	(Camuffo *et al.* 2007)
RSF2	Managing the quality of the material is primarily the responsibility of suppliers.	(Zsidisin *et al.* 2006)
RSF3	For reducing the loss caused by material defects, we propose a higher penalty for the supplier.	(Balachandran and Radhakrishnan 2005, Starbird 2001, Starbird 2005)
RSF4	If we have any loss due to defects or have any quality problems with the sourced materials (e.g. clients' penalty, product recall, unconditional replacement), we penalize the supplier additionally by asking for compensation.	(Baiman *et al.* 2000)
RSF5	We have laid down a detailed description of suppliers' responsibilities which will be applied if defects are found in the purchased materials.	(Hwang *et al.* 2006, Camuffo *et al.* 2007)
RSF6	If our product has a high potential risk in quality and safety, we would purchase product liability insurance.	(Berenson 1972a, Ritchie and Brindley 2007)
RSF7	We have product liability insurance to cover liability for losses or injuries to the consumer that are caused by product defects.	(Berenson 1972a, Ritchie and Brindley 2007)

4.4 RISK SHARING

In risk sharing, the firm wishes to maintain a long-term relationship with reliable and capable suppliers for providing quality components. The firm needs to develop a supply chain integration relationship with the suppliers while employing a risk sharing strategy (Camuffo *et al.* 2007). Thus, the buyer firm's managers need to make decisions about investing in the supplier's facility for the improvement of the product quality. Furthermore, the buyer firm also needs to invest in education and training to build the abilities in the supplier to ensure product quality and safety. These activities are then instigated by the purchasing firm in order to help in supplier development in terms of quality performance and capability (Zsidisin and Ellram 2003). When the quality and safety of the supplier's production can reach the required level, the buyer firm can delegate to suppliers the task of producing different components and can decide whether and how to share the risk arising from suppliers' production.

Risk sharing does not only include the activities that relate to sharing the negative consequence and sharing the responsibility to assure the product quality. Risk sharing often also intertwines with benefit sharing, since benefit is taken as an incentive to both parties to mitigate the SCQR together (Harland *et al.* 2003). For having a fair risk and benefit sharing, a mutually beneficial agreement system

between the firm and supplier is needed. Hence, an unambiguous statement is required for the justification of how the loss and benefit are being shared. To avoid the uncertainty of risk and benefit sharing, the firm and its supplier need to cooperate in joint product and process design. Harland *et al.* (2003) further stressed that an open dialogue was needed to agree on the allocation of risk between the two parties.

Looked at from the agency theory perspective, risk sharing is a behaviour-based practice. Zisidsin and Ellram (2003) mentioned that behaviour-based practice was a risk reduction strategy, and it was suitable to adopt when the supplier's uncertainty factor became significant. Behaviour-based practice is concerned with process, tasks and activities that lead to risk reduction (Harland *et al.* 2003). Task programmability relates as the level to which appropriate behaviour by the agent (supplier) can be specified in advance, and provides an easy way to measure behaviour (Eisenhardt 1989). Therefore, when a firm employs risk sharing, a template of activities is defined and approved by both buyer and seller firms (Zsidisin and Smith 2005, Zirpoli and Caputo 2002). In general, the more programmable the supplier's task, the easier it becomes for the buyer firm to control the supplier's behaviour. If the component is designed by both buyer and seller firms, it is easier to observe the supplier's product quality as information about the supplier's behaviour is more readily available. The buyer firm probably has a fairly

detailed knowledge, not only of the overall final product architecture, but also of the components the supplier manufactures. This implies that the transparency between the buyer firm and supplier is improved. Moreover, the buyer firm has full knowledge of the supplier's processes and even the cost structure. Task programmability can reduce information asymmetry between the buyer and seller firms (Camuffo *et al.* 2007).Thus, better supply chain coordination and monitoring of the supplier's manufacturing process can ensure the quality and safety of the product supplied (Madhusudan 2005, Marucheck *et al.* 2011). Moreover, the buyer firm can monitor supplier operations and behaviour by keeping track of the documents or statistical process control data of each manufacturing task which are sent back from the supplier (Aron *et al.* 2008, Lyles *et al.* 2008). This "keep on tracking" process can be viewed as a kind of risk monitoring, in which the SCQR in the supplier firm can be monitored to determine potentially increasing trends in probability or consequence (Hallikas *et al.* 2004).

A firm's risk sharing effort is measured through the following items: the extent of using inter-organizational collaboration to solve quality problems (RSR1, RSR2, RSR3 and RSR8), the effort of buyer firms to help the supplier to improve quality (RSR4 and RSR5), and the use of task programmability in supplier production to control product quality (RSR6 and RSR7). Table 4.3 lists the

measurement items in risk sharing.

Table 4.3 Measurement items in risk sharing

Item	Measurement items	Sample / Reference
RSR1	We regularly solve problems jointly with our key suppliers.	(Li *et al.* 2006)
RSR2	We help our key suppliers to improve their product quality in the long run.	(Li *et al.* 2006)
RSR3	We hold meetings with suppliers on a regular basis to solve quality problems.	(Stanley and Wisner 2001)
RSR4	We invest in our key supplier's facility to improve product quality.	(Baiman *et al.* 2000, Zhu *et al.* 2007)
RSR5	We provide training for suppliers on quality requirements.	(Stanley and Wisner 2001)
RSR6	We set up tasks and procedures for supplier production with our key suppliers.	(Camuffo *et al.* 2007, Lyles *et al.* 2008, Zsidisin and Ellram 2003)
RSR7	We require our key suppliers to return the documents or statistical process control (SPC) data so we can keep track of the production quality.	(Rungtusanatham *et al.* 1999, Lyles *et al.* 2008, Kaynak and Hartley 2008)
RSR8	We include key suppliers in the design stage of new products.	(Stanley and Wisner 2001)

4.5 RISK AVOIDANCE

The importance of risk avoidance is that it prevents poor quality and harmful materials from reaching the buyer firm. Risk avoidance is associated with sets of activities which aim to identify and protect against the SCQR before the material is processed and manufactured into a final product. These activities are mainly the

internal operations of the buyer firm that prevent negative risk incidents from happening. This definition is similar to the one made by Thun and Hoenig (2011). Thun and Hoenig (2011) claimed that the preventive practices are cause-related measures that the target of which is to lower the probability of risk occurrence. Moreover, Blome and Schoenherr (2011) claimed that risk avoidance is a proactive action to deal with risk, thus the risk suffered can be minimized.

To reduce the probability of SCQR occurrence, the basic nature of risk avoidance is to achieve a constant and small variance in the quality level of the product being purchased. Most of the firms have adopted prevention activities by conducting a thorough supplier evaluation. (McKinsey&Quarterly 2009, Handley and Benton 2009). Marucheck *et al.* (2011) stated that a risk prevention strategy should include product safety as an important factor in the supplier selection process. The cost associated with product liability and recall may turn the "low cost supplier" into a "high cost supplier" when the cost of quality and safety risk is also counted in the supplier evaluation (Grackin 2008, Marucheck *et al.* 2011). However, it is not enough to just conduct a thorough supplier evaluation in risk avoidance practice. Zisidisin *et al.* (2003b) stressed that the evaluation of risk factors in the supplier selection process was vital in supply risk management. Hence, perceived risk can be mitigated immediately while suppliers are selected and only those who are

considered low risk are retained. Also, contingency plans can be prepared in those circumstances where SCQR cannot be fully reduced (Zsidisin 2003b). Moreover, the firm's manager also needs to be aware of the potential risk from single sourcing. Single sourcing does not only raise the risk in material disruption. It also exposes the firm to SCQR if the whole batch of purchasing products is defective or contaminated. Thus, it seems to be a safety measure to procure materials from a dual or multi-source in order to reduce the probability of SCQR.

In order to prevent SCQR, managers should not only evaluate the potential risk while they select the supplier, but also identify the potential causes or sources of SCQR that may exist in the material (Norrman and Jansson 2004). Furthermore, while identifying the potential quality risk from the upstream supply chain, a firm needs to setup a proper incoming inspection strategy for different categories of products and evaluate their inspection data. Moreover, the inspection information can be useful in identifying potential SCQR from the upstream supply network (Roth *et al.* 2008, Tse and Tan 2011). For the purpose of preventing SCQR, a firm should require its supplier to adopt rigorous testing rules and new quality standards, such as RoHS (Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment) and REACH (Registration, Evaluation and Authorisation of Chemicals), and treat them as critical supplier selection requirements (Tang 2008).

Moreover, incoming inspection verifies conformance to specifications and provides indirect information on the supplier's quality-enhancement effort (Hwang *et al.* 2006). For the development of an inspection strategy, a firm also needs to consider the long term investment in improving the effectiveness of vision inspection and other automated technologies to a certain inspection level. Alternatively, a firm may adopt a third party inspection which may be more costly but in which the customer may have more confidence.

Thus, a firm's risk avoidance is measured effort through the following items: the use of a supplier quality management approach to avoid selecting unreliable suppliers (RVO1, RVO2, RVO3, RVO4, RVO5 and RVO7), the identification of potential quality and safety risks in the supplier's product (RVO6, RVO8, RVO9 and RVO12), and the action of inspecting incoming material to stop receiving defective and unsafe products (RVO10, RVO11, RVO12 and RVO13). In addition, RVO12 is intended to measure both the attention paid to risk identification and the effort made by the company to inspect the products. Table 4.4 lists the measurement items in the risk avoidance construct.

Table 4.4 Measurement items in risk avoidance

Item	Measurement items	Source / Reference
RVO1	We prevent suppliers from using unproven product/process technology.	(Zsidisin *et al.* 2006)
RVO2	We rely on a small number of high quality suppliers for providing key components.	(Shin *et al.* 2000)
RVO3	Product quality and safety are the crucial requirements in our supplier selection process.	(Kaynak and Hartley 2008, Shin *et al.* 2000, Marucheck *et al.* 2011)
RVO4	We carry out quality audit on suppliers on a regular basis.	(Stanley and Wisner 2001)
RVO5	We use dual or multiple supply sources for some materials.	(Zsidisin *et al.* 2006)
RVO6	The risk of suppliers acting opportunistically on product quality is considered (e.g. using a lower grade material).	(Handley and Benton 2009)
RVO7	We require our suppliers to follow rigorous testing rules to ensure product quality and safety.	(Tang 2008)
RVO8	We get quality information from suppliers to figure out potential quality problems in material.	(Zsidisin and Ellram 2003, Zsidisin and Smith 2005)
RVO9	We identify potential quality and safety threats in the material we purchase.	(Zsidisin *et al.* 2006)
RVO10	We employ a third party inspector for ensuring the quality of critical components we purchase.	(Hwang *et al.* 2006, Tang 2008)
RVO11	We undertake robust testing to ensure the material received is not defective.	(Roth *et al.* 2008, Tang 2008)
RVO12	We evaluate the incoming inspection report to determine if there are any potential quality problems in materials.	(Kaynak and Hartley 2008)

Item	Measurement items	Source / Reference
RVO13	Our inspection team makes a great effort to ensure our received materials meet the international safety standard (e.g. RoHS and REACH).	(Tang 2008)

4.6 RISK REMEDY

Risk remedy in this research is defined as the withdrawal process by which poor quality products are removed from the customer, and returned to the manufacturer (focal firm) or destroyed in order to dispose of them. The nature of this SCQRM practice is different from the other three, as risk shifting, risk sharing and risk avoidance aim to solve the problem of defective or unsafe components being sourced from the supply network. In principle, risk remedy aims to deal with the actual and suspected threats to safety or quality of the product that require intervention to protect customers' interests (BRC 2007), whether the threat originated from the supplier or from the manufacturing firm. According to the definition of Thun and Honig (2011), risk remedy is a reactive strategy that responds to the risk incident after it has occurred.

In this study, the remedy action not only limits the management activities to "recall" the product from the consumer, it also includes the actions to "withdraw" the problematic product from direct customers. In other words, remedy management

actions range from *recalling* the consumer's products to *withdrawing* the product from its direct buyers in the downstream supply chain. In general, the difference between "product recall" and "product withdrawal" is: "Product recall" is related to removing a product from the market when the product has reached the consumer, and they are advised to return it or dispose of it. "Product withdrawal" is related to removing the product from the market where the product is returned from the supply chain members (including manufacturers, packers, distributors, and retailers), and the consumer is not asked to return the product (BRC 2007). In the "recall" case, the management team usually has a struggle to remove the dangerous product from the market place. There are several actions that the firm needs to take with laboratory, trade association, as well as the press media. In the "withdrawal" case, there are two possibilities. The first is when the product is a safety threat, but the product is still in the middle of the supply chain and has not yet reached the consumers; the second is when the product only has a quality defect but is not harmful to the health of customers. Therefore, the firms may not advice the consumer to return the product, but the firm withdraws the defective product from its direct buyers (such as other manufacturing firms and distributors). Moreover, it is assumed that the firm will rework the defective product and provide a product replacement to the buyer.

While the poor quality products can harm the consumer, the firm's handling

of the recall process is one of the most important remedy actions to respond to the customer (Zhao *et al.* 2009, Dawar and Pillutla 2000). Dawar and Pillutla (2000) claimed that the method of handling product recall appeared to be a critical determinant of the product harm incident impact on consumer beliefs. There are many examples of poor handling of product recalls that have led to destructive results. For example, the Sanlu tainted milk incident was a classic example where a firm had to file for bankruptcy proceedings due to the delay in triggering the recall announcement that led to huge health liability claims.

This passive approach may entail delaying the recall process and/or trying to shift the responsibility to other firms or entities. These recalls tend to be issued much later in the investigation process and usually happen after serious consumer complaints have been made to the firm. Unfortunately, such recalls are often issued after serious injuries have been sustained or death of consumers has occurred (Chen *et al.* 2009).

In contrast, poor handling of product withdrawal may not cause a serious result. However, an ineffective withdrawal process is one of the most important purchase influences on the customer, for example, delays in replacing the defective product. Moreover, some products may have the problem of low durability or low reliability which the seller firm discovers only after the product has been delivered.

In such cases, the management team might choose not to tell the buyer firm as it may not cause an emergency. However, the firm's interest is still damaged as it does cause a higher warranty cost and the firm's reputation is spoiled in the long term.

Although the severity of the results of mishandling "recall" and "withdrawal" are different, the basic principles of handling them is the same, i.e. proactively recall/withdraw the product, returning the problematic product effectively, and replacing the defective product (Kumar and Budin 2006). A proper product recall/withdrawal strategy plan definitely improves the effectiveness of the returning process. Dawar and Pillutla (2000) and Heerde *et al.* (2007) stressed that there was a need to have a checklist before instigating a product recall. In a guide book provided by the British Retail Consortium (2007), the authors claimed that there are no "hard and fast" rules for preparing for a product recall/withdraw that is able to cover every circumstance, but a predefined plan can provide some guidelines as to how different parties in a supply chain should act and manage the unsafe/defective products. Hence, the better reactive activities can promptly manage the problematic products in the supply chain. The vital point of the plan is to make clear what the seller firm's responsibility is (Dawar and Pillutla 2000), and what the customer expects from the seller firm (BRC 2007).

Moreover, good preparation for a risk response, such as a proper product

recall/withdrawal strategy, can diminish the barrier to good financial performance (Zhao *et al.* 2009, Dawar and Pillutla 2000, Heerde *et al.* 2007). Some research suggests that a proactive recall strategy is the best way to respond to SCQR (Dawar and Pillutla 2000). If the firm or the government agency discovers a product flaw that might necessitate a potential recall, the firm adopting a proactive strategy is more likely to work with the agency and issue a voluntary recall early in the process. Such recalls often occur when the firm becomes aware of a potentially hazardous product through internal inspections and before any consumer safety incidents have been reported to the firm or agency. On the other hand, triggering a proactive product withdrawal for a product flaw can mitigate the warranty cost and provide a good customer relationship in the long run. Thus, a firm's risk remedy effort is measured mainly through preparation for product recall/withdrawal and by having an attitude of being ready and willing proactively to recall/withdrawal any defective products. The construct of risk remedy includes the following items: the extent of preparation for product withdrawal and recall (RRY1 and RRY7), the willingness to withdraw/recall and replace problematic products (RRY2 and RRY3), and the appropriate actions of managing recall/withdrawal (RRY4, RRY5 and RRY6). Table 4.5 lists the measurement items in the risk remedy construct.

Table 4.5 Measurement items of risk remedy

Item	Measurement items	Sample / Reference
RRY1	We have set up a product recall/withdrawal strategy.	(Siomkos and Kurzbard 1994, Heerde *et al.* 2007)
RRY2	We recall/withdraw the products from our customers proactively if the products are defective.	(Siomkos and Kurzbard 1994, Heerde *et al.* 2007)
RRY3	If our product has a quality problem, we will unconditionally replace the defective products.	(Siomkos and Kurzbard 1994, Chen *et al.* 2009)
RRY4	We have a slow response in recalling/withdrawing defective products. (reverse code)	(Siomkos and Kurzbard 1994, Heerde *et al.* 2007)
RRY5	If our product has a quality problem, we will have an unambiguous assumption of responsibility.	(Dawar and Pillutla 2000)
RRY6	We investigate the cause of product recall/withdrawal in order to avoid it happens again.	(Dawar and Pillutla 2000)
RRY7	Checklists are typically provided detailing the appropriate managerial actions to follow when we need to recall/withdraw a product.	(Dawar and Pillutla 2000, Heerde *et al.* 2007)

Remarks: The Chinese translation for "product recall" uses the same words as for "product withdrawal"..

4.7 DISCUSSION

This study specifically advances the current knowledge of SCRM and strives to construct a more comprehensive view of SCQRM by integrating the perspective of SCM, OM and RM. This study makes several theoretical contributions in advancing the knowledge of SCRM. In the previous studies, scholars mostly focused on some specific practices for reducing quality problems in the supply chain. For example, recall management to manage the negative consequences (Kumar and Budin 2006, Kumar and Schmitz 2011, Gray *et al.* 2011), supply chain quality management to enhance supplier product quality (Yeung 2008). However, there is a lack of an overview in risk management to solve SCQR. In this chapter, we consolidate the most recent literature related to SCQRM to define four distinctive dimensions. These four dimensions can be split into two pairs, i.e. prevent-react and risk allocation. The "prevent-react" group involves *ex ante* and *ex post* actions in which both of them aim to reduce the probability and impact of SCQR. The difference is that risk avoidance (*ex ante*) is used to reduce upstream SCQR before it brings the negative consequence to the firm; risk remedy (*ex post*) is used to reduce the negative consequences after SCQR has taken place. In addition, risk avoidance can be used to reduce the quality uncertainty caused by product design flaws (as mentioned in section 2.3.1.3), since the firm can shield against unsafe products by

setting up a proper inspection strategy for incoming products, with reference to global safety standards. Another group, risk allocation consists of risk shifting and risk sharing, these two dimensions are conceptualized with reference to the concepts of agency theory. According to agency theory, risk shifting is an outcome-based practice which focuses on the outcome, i.e. risk is reduced by the supplier regardless of how the supplier achieves it. Risk sharing is a behaviour-based practice the aim of which is to control the supplier's behaviour and to reduce the supplier's opportunism. It can be achieved by employing task programmability in supplier production so as to monitor the supplier quality effort. Moreover, the behaviour-based approach can effectively reduce the uncertainty from supply chain structure (mentioned in section 2.3.1.2) and manufacturing flaws (mentioned in section 2.3.1.3), since task programmability can help in reducing the information asymmetry between the buyer and seller firms. Therefore, the buyer firm can more closely monitor the production process, and notice any unallowable re-outsourcing activity in the supplier firm. Moreover, the uncertainty of design flaw can also be reduced, as the tasks and procedures of supplier production are established by both supplier and buyer firms. Thus, the hidden design-flaw would be more likely to be discovered when the quality experts in both firms are involved in designing the production tasks.

Moreover, the operationalization of SCQRM has broadened the traditional

measures rooted in supplier management. This study points out that there is a need to include measurement items of strategic supplier management in the literature. For example, Shin *et al.* (2000), Stanley and Wisner, (2001) ad Li *et al.* (2006). These items represent various concepts related to supplier management, including "strategic supplier partnership" (Li *et al.* 2006), "cooperative purchasing" (Stanley and Wisner 2001), "supplier quality management" (Kaynak and Hartley 2008), and "buyer-supplier management" (Shin *et al.* 2000). Both supplier selection and supplier collaboration are merged into a single concept of supplier management (Stanley and Wisner 2001). In contrast, these items are perceived to belong to two different dimensions in SCQRM, i.e. risk sharing and risk avoidance. In this study, these two activities are conceptualised into two different dimensions as their basic natures in SCQRM are different, i.e. supplier collaboration is the foundation of risk sharing, and supplier selection involves the activities needed in order to "avoid" SCQR. Most of the measurement items in risk sharing and risk avoidance are borrowed from the existing literature, and they have been justified and amended according to the nature of differences in SCQRM. The justification information of these borrowed items is summarized and included in Appendix 1.

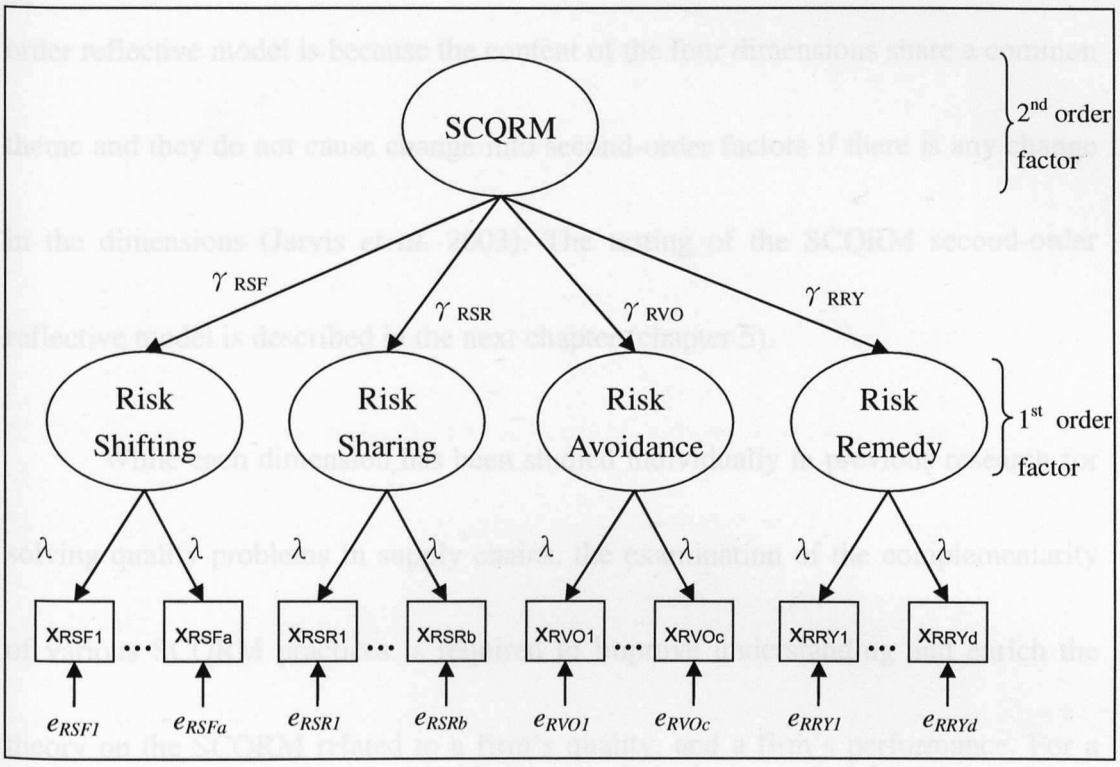

Figure 4.5 Conceptual model of SCQRM dimensions

Figure 4.5 shows the conceptual SCQRM model. The SCQRM construct as proposed is multidimensional. The dimensions are critical and replicable *complementarity* for reducing SCQR. Moreover, the multidimensionality and underlying complementarity of the SCQRM are represented by a second-order factor model (Menor and Roth 2007, Edwards 2001). SCQRM is conceptualized as a multi-dimensional reflective indicator construct. A series of first-order factors with reflective indicators, and also the first-order factors themselves, are reflective indicators of second-order factors. The reflective nature is shown by the direction of the arrow. If the arrows point from the factor to the indicator, then the factor is claimed as a reflective factor. The major reason for proposing SCQRM as a second-

order reflective model is because the content of the four dimensions share a common theme and they do not cause change into second-order factors if there is any change in the dimensions (Jarvis *et al.* 2003). The testing of the SCQRM second-order reflective model is described in the next chapter (chapter 5).

While each dimension has been studied individually in previous research for solving quality problems in supply chains, the examination of the complementarity of various SCQRM practices is required to improve understanding and enrich the theory on the SCQRM related to a firm's quality, and a firm's performance. For a better understanding of the "complementarity" nature of SCQRM practices, the test should be linked to the discussion of "how each complementary practice (i.e. each SCQRM practice) affects the firm's performance". The theoretical arguments of complementarity effect in SCQRM and its empirical testing results are further discussed in chapter 6.

4.8 CHAPTER SUMMARY

This study makes several theoretical contributions to the advancement of knowledge about SCQRM. The author strives to construct a more comprehensive view of SCQRM by integrating strategic risk allocation, and prevent-react risk

treatment into a risk management system for handling SCQR and its consequences.

SCQRM is proposed as a multi-dimensional construct with four distinctive dimensions: risk shifting (RSF), risk sharing (RSR), risk avoidance (RAV) and risk remedy (RRY). Risk shifting is the practice that aims to transfer the economic loss of SCQR to other business partners. The uncertainty of loss from SCQR can be reduced by risk shifting, since a firm can penalize a supplier's defects and the penalty can act as a buffer for the economic loss of SCQR. Risk sharing is related to cooperative activities by which both supplier and buyer improve the product quality by collaboration. Quality uncertainty is reduced by task programmability in which the supplier activities can be controlled by a template of production procedures. This template of procedures is planned by both supplier and buyer parties. Risk avoidance includes the preventive activities to shield the firm from SCQR. Quality uncertainty is reduced by a thorough supplier selection process for choosing a reliable supplier. Also, a proper inspection strategy is adopted to stop defective and unsafe materials from entering the firm, and the inspection data can be used to investigate the potential quality risk from the supply network. Risk remedy aims to reduce the negative consequences of SCQR after it has actually occurred.

Moreover, the operationalization of SCQRM has contributed to SCM and RM empirical research. Plenty of potential measurement items of each SCQRM

practice are proposed. The measurement items representing risk shifting and risk remedy are newly developed since no existing measurement item for these two concepts is presented in the literature. For the measurement items of risk sharing and risk avoidance, some of them originated from the literature related to supplier management. These items have been modified and adjusted to suit the concepts of risk sharing and risk avoidance. In order to further enhance the managerial and theoretical understanding of SCQRM, the reliability and validity of generated multi-dimensional measurement items are assessed by a rigorous 7-stage scale development process which is described in the next chapter.

CHAPTER 5. SCALE DEVELOPMENT OF SUPPLY CHAIN QUALITY RISK MANAGEMENT

5.1 INTRODUCTION

In this chapter, multi-item measurement and scale development for supply chain quality risk management (SCQRM) are discussed. As mentioned in chapter 1 and chapter 2, there is a lack of "off-the-shelf" measurement items for SCQRM in the literature. Measurement is an important element for extending the fundamental body of knowledge in supply chain risk management (SCRM) (Churchill 1979). An effective measurement instrument is a prerequisite for good empirical science (Menor and Roth 2007), and it should cover the content domain of each construct (Li *et al.* 2005).. In this chapter, 7 stages of scale development procedures are followed in order to develop and validate the proposed dimensions which constitute SCQRM.

In the 7-stage scale development process referred to in the methodology chapter (chapter 3), there is a "loop" between stage 2 and stage 3 (see Figure 5.1). The purpose of this "loop" is to ensure that the conceptual domain, SCQRM, is well conceptualized and operationalized. In this study, stage 3 has been repeated, as the result of the first-round of the content validity test of the scale items was not satisfactory. The expert panel provided valuable feedback regarding the constructs and useful comments on the content validity of the proposed items. The items were

revised and the definitions of SCQRM dimensions were re-specified in accordance with the feedback from the expert panel. The revised scale items were presented in the last chapter.

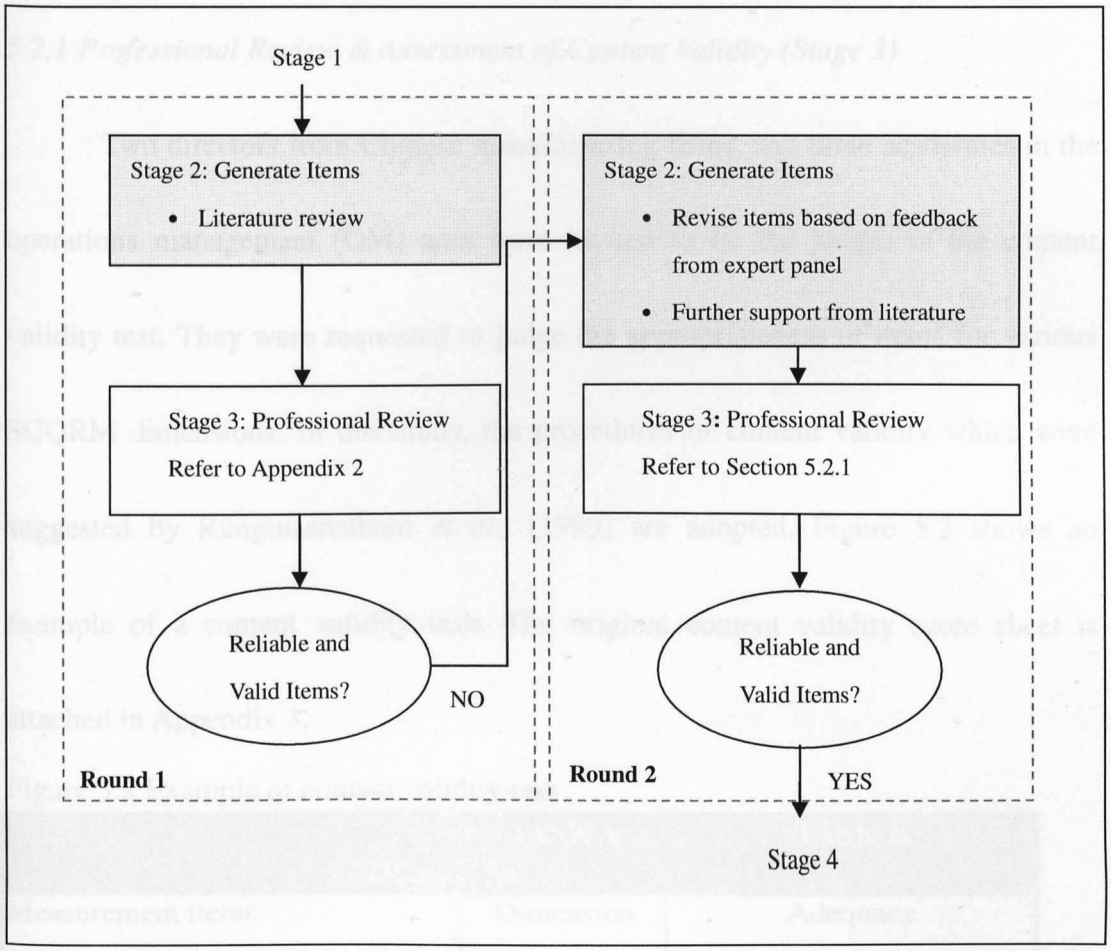

Figure 5.1 Stage 2 and Stage 3 flow diagram

In this chapter, only the second-round of stage 3 is described. The details of the previous version of SCQRM scale items and the expert panel's feedback are included in Appendix 2.

5.2 DATA ANALYSIS AND RESULTS

In the last chapter, the conceptualization of the SCQRM dimensions and the

generation of new item measures in SCQRM were clearly described. Thus, this section starts at stage 3 (second-round) to go through the following steps to validate the generated items.

5.2.1 Professional Review & Assessment of Content Validity (Stage 3)

Two directors from Chinese manufacturing firms, and three academics in the operations management (OM) area were invited to be the judges in the content validity test. They were requested to judge the appropriateness of items for various SCQRM dimensions. In this study, the procedures of content validity which were suggested by Rungtusanatham *et al.*, (1999) are adopted. Figure 5.2 shows an example of a content validity task. The original content validity score sheet is attached in Appendix 3.

Figure 5.2 Example of content validity task

	TASK A	TASK B						
Measurement items	Dimension	Adequacy						
		1	2	3	4	5	6	7
10. We regularly solve problems jointly with our key suppliers.	**2**				X			

First, a score sheet which contained the operational definition of four SCQRM dimensions and a random listing of 35 measurement items was given to each judge. The judges were requested to use the operational definitions to guide

them to categorize the items into no more than one dimension (i.e. Task A). The result of task A was used to compute the Cohen's kappa (κ) value. Kappa value is an indication of beyond–chance agreement among the judges on the overall task (Rungtusanatham 1998, Cohen 1960).

Table 5.1 shows the content validity result. The test finds all the items reaching the minimum cut-off point (60%) in "the percent of judges assigning the item to the correct dimension", except RVO8. RVO8 only scored 40%. Thus, it is the first item to be removed from the items pool. After dropping RVO8, the Cohen's kappa value is 0.762, which is a good inter-judge agreement. The standard deviation for Cohen's kappa (σ_κ) was 0.07, yielding a 95 percent confidence interval for the kappa in the interval [0.62, 0.90]. Moreover, the z-test (Rungtusanatham 1998) which was adopted to confirm the statistical significance of kappa shows that the observed inter-judge agreement as to the sorting of the measurement items did not occur by chance.

In Task B, the judges need to rate the adequacy of the item based on a 7-point scale. The aim of task B is to test how adequately each measurement item measures the dimension. The 7-point response scale ranges from "1" as barely adequate to "7" as almost perfect. After collecting the data in Task B, the average adequacy score and standard deviation of adequacy of each measurement item are computed and

evaluated.

As shown in Table 5.1, all 35 items score quite good average adequacy scores (>5.0), except for RVO8. The standard deviation of items RVO8 and RRY4 are 1.517 and 1.095 respectively. These values are higher than the acceptable standard deviation (≤ 1.00) (Rungtusanatham *et al.* 1999). It was decided to keep RRY4 as it scored 5.80 on average, and the standard deviation value was only a little higher than the acceptable level. Finally, only one item (RVO8) had to be removed at this stage. Thus, both "the percent of judges assigning the item to the correct dimension" and the "standard deviation" show that only RVO8 needs to be removed from the content validity test.

Table 5.1 Content/Face Validity Assessment Result

Proposed SCQRM dimensions	Proposed Measurement Item	Average Adequacy Score	Sample Standard Deviation	% of judges assign the item to the correct dimension
Risk Shifting (RSF)	RSF1	6.60	0.548	100%
	RSF2	7.00	0.000	100%
	RSF3	6.40	0.548	100%
	RSF4	5.80	0.837	100%
	RSF5	6.80	0.447	100%
	RSF6	6.60	0.548	100%
	RSF7	6.40	0.548	100%
Risk Sharing (RSR)	RSR1	6.20	0.447	60%

Proposed SCQRM dimensions	Proposed Measurement Item	Average Adequacy Score	Sample Standard Deviation	% of judges assign the item to the correct dimension
	RSR2	6.00	0.707	60%
	RSR3	5.60	0.894	80%
	RSR4	6.60	0.548	100%
	RSR5	6.20	0.447	60%
	RSR6	6.00	0.000	100%
	RSR7	6.00	0.707	100%
	RSR8	6.40	0.548	100%
Risk Avoidance (RVO)	RVO1	6.00	1.000	60%
	RVO2	5.80	0.837	100%
	RVO3	6.20	0.837	100%
	RVO4	6.20	0.837	80%
	RVO5	5.60	0.894	60%
	RVO6	5.60	0.548	100%
	RVO7	6.60	0.548	100%
	RVO8	4.40	1.517	40%
	RVO9	6.80	0.447	100%
	RVO10	6.60	0.548	100%
	RVO11	6.20	0.837	100%
	RVO12	6.80	0.447	100%
	RVO13	6.60	0.548	100%
Risk Remedy (RRY)	RRY1	6.40	0.894	100%
	RRY2	6.40	0.894	100%
	RRY3	6.60	0.894	100%
	RRY4	5.80	1.095	100%
	RRY5	5.80	0.447	60%
	RRY6	6.40	0.894	100%
	RRY7	6.20	0.837	100%

5.2.2 Questionnaire Design (Stage 4)

5.2.2.1 Questionnaire Format

After finalizing the measurement items, there are seven items for risk shifting (RSF), eight items for risk sharing (RSR), twelve items for risk avoidance (RVO), and seven items in risk remedy. A 7-point Likert scale was adopted to indicate the extent to which respondents agree or disagree with each question item where 1 = strongly disagree and 7 = strongly agree. According to Hinkin (1995), in order to ensure the reliability of the measurement, each construct should contain at least three items, since the measurement scales with too few items will cause problems related to a decrease in content validity, construct validity, and internal consistency. Moreover, the construct will face the "underidentified" problem if the number of variables is less than three (Hair *et al.* 2009).

5.2.2.2 Translation of Questionnaire

Since the target respondents were directors and senior managers in Chinese firms, the questionnaire was translated into Chinese. Two scholars in Hong Kong are consulted in order to ensure the measurement items in Chinese reflected the organizational environment that Chinese firms face. In accordance with the advice of Brislin (1980), the Chinese questionnaire was subsequently translated back into English by a third party translator to make sure that the measurement items

accurately reflect the original meanings. These two sets of the English questionnaire were carefully reviewed, and there was no significant change in the English wording after the questionnaire had been re-translated. Both the finalised English and Chinese questionnaires are attached in Appendix 4.

5.2.2.3 Pilot Test

Directors from two different manufacturing firms and three academics were invited to review the refined questionnaire in both English and Chinese versions. Moreover, they were invited to assess the readability of the representative measurement items. Face-to-face discussions were conducted in order to obtain their advice on how to improve the readability of questionnaire items. One of the industrialists suggested that the term - "risk" should not be used in the items, as the meaning of the term "risk" might be too abstract in Chinese translation and sensitive for some informants. He stated that using the term "risk" as the key word of the title may hinder them from completing the survey. Therefore, some of the question items are modified based on this comments. In the second round, the question items were further evaluated by a panel of staff members in *The Institute for Supply Management, Pearl River Delta (ISM-PRD).* Discussions over the phone were conducted to make sure there was no misunderstanding of the items and to receive their suggestions for amendments. Only a few words were changed in the question

items because of English-Chinese translation problems.

5.2.3 Data Collection, Questionnaire Administration, & Data Purification (Stage 5)

5.2.3.1 Data Collection and Questionnaire Administration Procedure

The unit of analysis of this study focuses on the adoption of SCQRM in a single firm. A director or senior manager of each firm is the target informant. Data was collected through a survey of Hong Kong manufacturing firms with all of them having their own plants in the China, Pearl River Delta (PRD) region.

The research objectives are best achieved by obtaining responses from relevant managers and presenting a diverse set of SCQRM practices geared to solving quality and safety problems. Three email contacts were made with the potential informants including a pre-notice, the primary invitation letter (see Appendix 5) along with a survey link. Since this research is endorsed by two associations, *Institute of Purchasing and Supply Hong Kong (IPSHK)* and *The Institute for Supply Management, Pearl River Delta (ISM-PRD)*, the email carried with it either IPSHK, or ISM-PRD endorsement letters (see Appendix 6). A merged contact list containing contact information of 4505 firms dealing in apparel, furniture, plastics, metal, computer equipment, electronics, measuring instrument manufacturing industries (SIC: 23, 25, 30, 34, 35, 36, 38, and 39) in Hong Kong and PRD regions was used in this research. The US standard industrial classification

(SIC) was used for the categories since it is the most used classification in top operations management journals. The survey questionnaires were sent via email over 12 weeks (12/2010-2/2011), and then there was a follow up email/call to remind the key informants to respond. A total of 320 survey questionnaires were received representing 6 % response rate. Moreover, in this study, a complete case approach was adopted to deal with the missing data (i.e. the respondent is eliminated if missing data on any variable) (Hair *et al.* 2009). Therefore, only 289 copies of the questionnaire were valid, 31 responses were deleted. Table 5.2 shows the information of the respondents.

Table 5.2 Respondents table (N=289)

Title of respondent	Percent		Organization annual revenue	Percent
Director/CEO/Vice President	33.2%		Less than HK$10 million	23.5%
Purchasing Manager	29.4%		Between HK$10 million and HK$50 million	41%
Supply Chain Manager	7.3%		Between HK$50 million and HK$200 million	26%
Quality Manager	12.5%		More than HK$200 million	9.5%
Project Manager	10.7%			
Others	6.9%			

SIC	Industry description	Percent
23	Apparel and other finished products made from fabrics and similar materials	0.7%
25	Furniture and fixtures	3.5%
30	Rubber and miscellaneous plastics products	14.2%
34	Fabricated metal products, except machinery and transportation equipment	8.0%
35	Industrial and commercial machinery and computer equipment	27%
36	Electronic and other electrical equipment and components, except for computer equipment	33.6%
38	Measuring, analyzing, and controlling instruments; photographic, medical and optical goods	1%
39	Miscellaneous manufacturing industries	12.1%

Firm Size	Percent
<=50	21.5%
51-200	37%
201-500	20.8%
501-1000	9.7%
>1000	11.1%

5.2.3.2 Data Purification

Non-response bias is usually evaluated by two methods. The first test is to assess significant differences between the early respondents and later respondents (Swafford *et al.* 2006). The second one is to test the significant differences between the respondents and non-respondents. Since the mail-list provided parties did not provide the firm size and annual-sales of the non-respondents, this section only assesses the early respondents and later respondents. The late responses can be considered as a surrogate for non-respondents (Armstrong and Overton 1977). According to the classic procedure suggested by Armstrong & Overton (1977), researchers can conduct the χ^2 tests to show that the early respondents and later respondents firms share the same distribution of organizational size and annual sales at $p<0.05$. By employing this method, the first received 50 questionnaires (early responses) are compared with the last 50 questionnaires (late responses) (Swafford *et al.* 2006). The result shows that χ^2 tests indicate no statistical differences at $p<0.05$ when comparing organizational size ($p=0.713$) and annual sales ($p=0.411$) between the early response and late response groups.

5.2.3.3 Sample size

According to recommendations of Hinkin (1995), the item-to-response ratios should range from 1:4 (Rummel 1970) to 1: 10 (Schwab 1980) for the factor analysis of the scale. There were altogether 289 usable questionnaires, so the adequacy of item-to-response ratio is far beyond the recommended minimum ratio.

5.2.4 Scale Construction and Purification (Stage 6)

Before starting EFA, the correlations among the item measures in the construct are assessed. The items which "correlated negatively" or "weakly correlate with other items" in the same construct were removed. The correlation results are listed in Table 5.3 to Table 5.6. There is no negative correlation in any item in their constructs. Moreover, RRY4 and RVO2 are the problematic items as they correlate weakly with half of the items in the same construct. The EFA test was conducted to further confirm the deletion of these two items.

Table 5.3 Pearson Correlation Coefficient between items of RSF

Pearson Correlation	RSF1	RSF2	RSF3	RSF4	RSF5	RSF6
RSF2	0.566**					
RSF3	0.318**	0.454**				
RSF4	0.398**	0.378**	0.510**			
RSF5	0.307**	0.315**	0.556**	0.687**		
RSF6	n.s.	w.c.	0.287**	0.396**	0.435**	
RSF7	n.s.	n.s.	0.246**	0.314**	0.405**	0.648**

** *Correlation is significant at the 0.01 level (2-tailed); n.s. indicates the correlation is not significant; w.c. indicates the two items correlate weakly*

Table 5.4 Pearson Correlation Coefficient between items of RSR

Pearson Correlation	RSR1	RSR2	RSR3	RSR4	RSR5	RSR6	RSR7
RSR2	0.650**						
RSR3	0.543**	0.611**					
RSR4	0.216**	0.416**	0.316**				
RSR5	0.335**	0.483**	0.523**	0.523**			
RSR6	0.466**	0.515**	0.653**	0.653**	0.690**		
RSR7	0.391**	0.381**	0.379**	0.379**	0.474**	0.536**	
RSR8	0.317**	0.334**	0.369**	0.369**	0.448**	0.526**	0.480**

** *Correlation is significant at the 0.01 level (2-tailed)*

Table 5.5a Pearson Correlation Coefficient between items of RVO (1)

Pearson Correlation	RVO1	RVO2	RVO3	RVO4	RVO5	RVO6
RVO2	0.302**					
RVO3	0.364**	w.c.				
RVO4	0.465**	0.203**	0.752**			
RVO5	0.301**	0.299**	0.438**	0.525**		
RVO6	0.368**	0.219**	0.631**	0.676**	0.533**	
RVO7	0.425**	0.227**	0.484**	0.542**	0.539**	0.530**
RVO9	0.402**	w.c.	0.446**	0.465**	0.389**	0.516**
RVO10	w.c.	w.c.	0.431**	0.407**	0.286**	0.344**
RVO11	0.344**	w.c.	0.585**	0.627**	0.530**	0.588**
RVO12	0.336**	w.c.	0.495**	0.514**	0.522**	0.528**
RVO13	0.335**	w.c.	0.450**	0.431**	0.394**	0.434**

** *Correlation is significant at the 0.01 level (2-tailed); n.s. indicates the correlation is not significant; w.c. indicates the two items correlate weakly*

Table 5.5b Pearson Correlation Coefficient between items of RVO (2)

Pearson Correlation	RVO7	RVO9	RVO10	RVO11	RVO12
RVO9	0.544**				
RVO10	0.351**	0.389**			
RVO11	0.606**	0.538**	0.392**		
RVO12	0.532**	0.554**	0.313**	0.657**	
RVO13	0.534**	0.445**	0.339**	0.617**	0.638**

** *Correlation is significant at the 0.01 level (2-tailed)*

Table 5.6 Pearson Correlation Coefficient between items of RRY

Pearson Correlation	RRY1	RRY2	RRY3	RRY4	RRY5	RRY6
RRY2	0.463**					
RRY3	0.456**	0.691**				
RRY4	n.s.	w.c.	0.240**			
RRY5	0.369**	0.474**	0.438**	0.275**		
RRY6	0.307**	0.551**	0.519**	w.c.	0.518**	
RRY7	0.504**	0.387**	0.368**	w.c.	0.510**	0.489**

** *Correlation is significant at the 0.01 level (2-tailed); n.s. indicates the correlation is not significant; w.c. indicates the two items correlate weakly*

5.2.5 Assessment of Unidimensionality

The unidimensionality of the SCQRM components is addressed by using EFA. All the measurement items are aggregated to run EFA. The varimax method is adopted in EFA since it is one of the most used EFA rotation methods. First, the Kaiser-Meyer-Olkin test (KMO) is run for testing the sampling adequacy. The result shows that KMO was computed to be 0.917. That is much greater than the suggested criteria 0.60 (Worthington and Whittaker 2006), and indicates the sample adequacy for running EFA. The Eigenvalues for the four constructs are greater than 1.0. RSR8, RVO10 and RRY4 are dropped as the percentage of variance of the items extracted in communality are smaller than 0.50. It shows that these items have a low proportion of variance that is shared with other items. Moreover, RVO9 is the

boundary case since it scores 0.488 in variance extracted in commonality. It was decided to keep it as there is only a very small difference. Moreover, RSF6, RSF7, RSR1, RSR7, RVO2, and RVO13 were dropped as they are highly cross-loaded with other factors. In summary, the undimensionality of each dimension is supported, and altogether 24 items are retained. The EFA test results of the remaining items are shown in Table 5.7. The Cronbach's alpha test was adopted to assess the consistency of the entire scale. All items in each dimension of SCQRM fulfill the criteria of reliability required by Cronbach's alpha >0.70 (Hair *et al.* 2009).

Table 5.7 Exploratory Factor Analysis

	Factor 1 - Risk shifting Eigenvalue=1.532 Percentage of Variance=4.51% Cronbach's α=0.799	Factor 2 -Risk sharing Eigenvalue=2.43 Percentage of Variance=7.14% Cronbach's α=0.841	Factor 3 -Risk avoidance Eigenvalue=11.93 Percentage of Variance=35.10% Cronbach's α=0.906	Factor 4 -Risk remedy Eigenvalue=2.12 Percentage of Variance=6.24% Cronbach's α=0.840
RSF1	0.613			
RSF2	0.667			
RSF3	0.716			
RSF4	0.750			
RSF5	0.684			
RSR2		0.657		
RSR3		0.629		
RSR4		0.693		
RSR5		0.759		
RSR6		0.745		
RVO3			0.651	
RVO4			0.688	

	Factor 1 - Risk shifting Eigenvalue=1.532 Percentage of Variance=4.51% Cronbach's α=0.799	Factor 2 -Risk sharing Eigenvalue=2.43 Percentage of Variance=7.14% Cronbach's α=0.841	Factor 3 -Risk avoidance Eigenvalue=11.93 Percentage of Variance=35.10% Cronbach's α=0.906	Factor 4 -Risk remedy Eigenvalue=2.12 Percentage of Variance=6.24% Cronbach's α=0.840
RVO5			0.708	
RVO6			0.683	
RVO7			0.663	
RVO9			0.576	
RVO11			0.709	
RVO12			0.639	
RCR1				0.571
RCR2				0.783
RCR3				0.750
RCR5				0.595
RCR6				0.655
RCR7				0.487

5.2.6 Scale Validation (Stage 7)

5.2.6.1 Assessing Model Fitness by Comparing with Competing Models

At this stage, three measurement models are analysed to establish the dimensional structure of SCQRM practice by using CFA: Harman's one-factor model (model 1), four-uncorrelated factor models (model 2), and four-correlated factor models (model 3). The fit statistics are shown in Table 5.8, the model fitness is assessed according to the values of the fit indices, including χ^2 (*df*), RMSEA, CFI, NNFI, NFI , Normed χ^2, SRMR and PNFI. The *one-factor model* conceptualizes all

19 items into one unidimentional factor. All variances of 19 items are accounted for in one single construct. It is shown that model 1 has a poor fit. Model 2 is a *null model* in that all correlations among the four dimensions of SCQRM are 0. This proves that a multidimensional model composed of four uncorrelated first order factors is superior to a unidimensional first order model.

Model 3 conceptualizes that the four factors are freely correlated with each other (see Figure 5.3). The fit indices of model 3 match the acceptable model fit suggested by Shah and Goldstein (2006) (see Table 3.1). The model fit of model 3 is much better than model 2. This indicates that model 3 represents data better than model 2. Moreover, the χ^2 difference of model 2 and 3 is significant (delta χ^2=351.43, p-value<0.01). This shows the correlated model (model 3) is superior to model 1 and model 2. In other words, the model with SCQRM's four dimensions significantly and positively correlating with each other's practices has a stronger fit to sample data than the other two models.

Table 5.8 Fitness performance of alternative models

Model	χ^2 (df)	RMSEA [90% confidence interval]	CFI	NNFI	NFI	Normed χ^2 (χ^2/df)	SRMR	PNFI
Model 1	1046.26(152)	0.143 [0.135, 0.151]	0.899	0.887	0.882	6.883	0.0908	0.784
Model 2	703.55 (152)	0.112 [0.104, 0.121]	0.934	0.926	0.916	4.629	0.275	0.815
Model 3	352.12 (146)	0.070 [0.0607, 0.0794]	0.975	0.971	0.957	2.412	0.0495	0.817

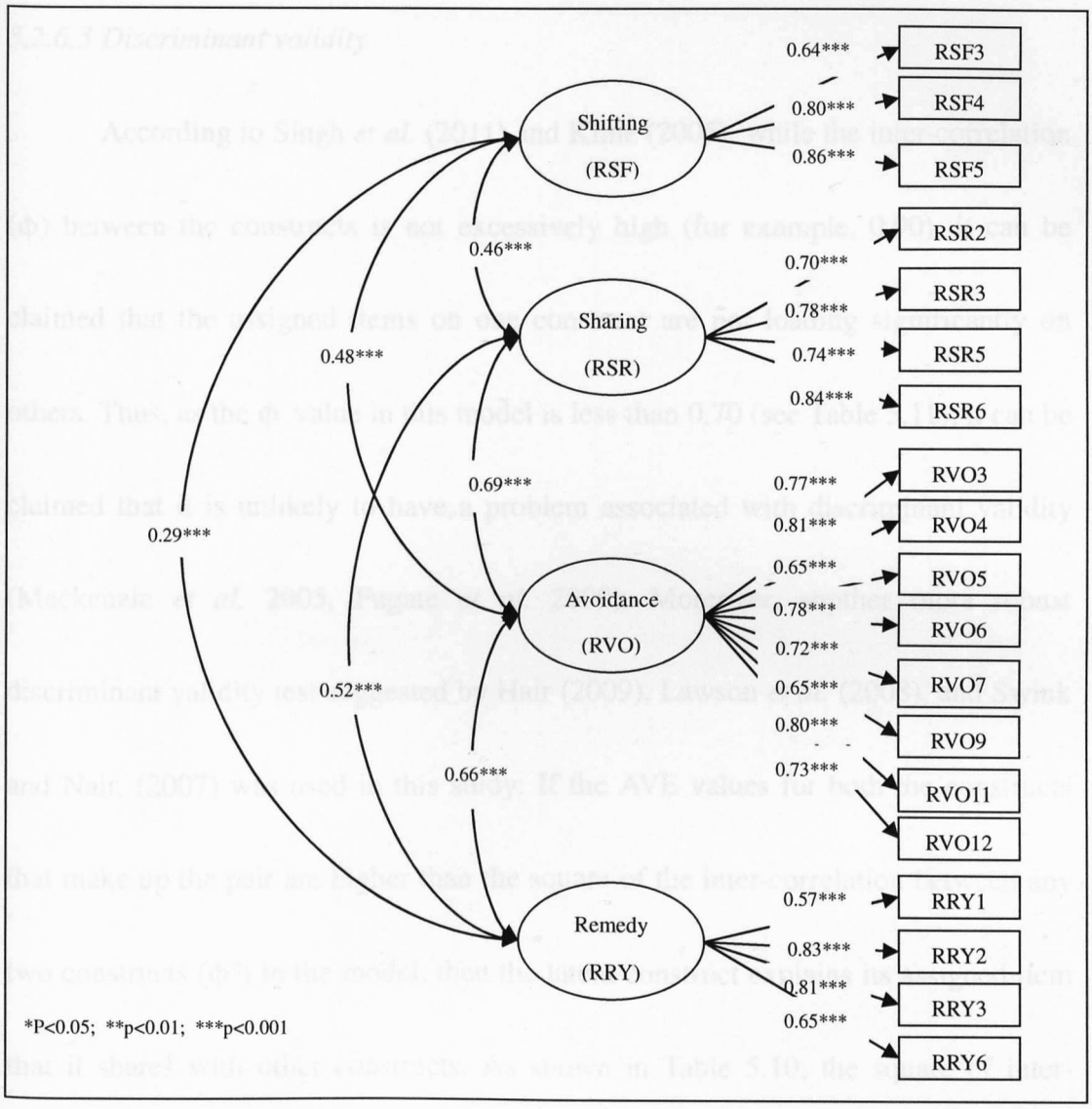

Figure 5.3 First-order SCQRM factor model

5.2.6.2 Convergent Validity

As shown in Table 5.9, all factor loadings (λ) are greater than 0.50. All the composite reliabilities are greater than 0.70. In Table 5.10, is a list of all the AVE values that are higher than 0.50. Based on these results, the scales show acceptable convergent validity.

5.2.6.3 Discriminant validity

According to Singh *et al.* (2011) and Kline (2005), while the inter-correlation (ϕ) between the constructs is not excessively high (for example, 0.90), it can be claimed that the assigned items on one construct are not loading significantly on others. Thus, as the ϕ value in this model is less than 0.70 (see Table 5.11), it can be claimed that it is unlikely to have a problem associated with discriminant validity (Mackenzie *et al.* 2005, Fugate *et al.* 2009). Moreover, another more robust discriminant validity test suggested by Hair (2009), Lawson *et al.* (2008), and Swink and Nair, (2007) was used in this study: If the AVE values for both the constructs that make up the pair are higher than the square of the inter-correlation between any two constructs (ϕ^2) in the model, then the latent construct explains its assigned item that it shares with other constructs. As shown in Table 5.10, the square of inter-correlation (ϕ^2) value of all six pairs is smaller than the AVE values of each construct, so this provides good evidence of discriminant validity (Fornell and Larcker 1981a).

Table 5.9 Result of Confirmatory Factor Analysis

Confirmatory Factor Analysis (N=289)	**Standardized Factor loading λ (standard error)**	**t-value**	**Composite Reliability**
RSF3: For reducing the loss caused by material defects, we propose a higher penalty for the supplier.	0.64 (0.60)	-------	0.813
RSF4: If we have any loss due to defects or have any quality problems with the sourced materials (e.g. clients' penalty, product recall, unconditional replacement), we penalize the supplier additionally by asking for compensation.	0.80 (0.37)	10.484	
RSF5: We have laid down a detailed description of suppliers' responsibilities which will be applied if defects are found in the purchased materials.	0.86 (0.27)	10.571	
RSR2: We help our key suppliers to improve their product quality in the long run.	0.70 (0.51)	------	0.849
RSR3: We hold meetings with suppliers on a regular basis to solve problems.	0.78 (0.39)	11.810	
RSR5: We provide training for suppliers on quality requirements.	0.74 (0.46)	11.224	
RSR6: We set up tasks and procedures for supplier production with our key suppliers.	0.84 (0.30)	12.413	
RVO3: Product quality and safety are the crucial requirements in our supplier selection process.	0.77 (0.41)	------	0.953
RVO4: We carry out a quality audit on suppliers on a regular basis	0.81 (0.35)	14.475	
RVO5: We use dual or multiple supply sources for some materials.	0.65 (0.58)	11.272	

Confirmatory Factor Analysis (N=289)	***Standardized Factor loading λ (standard error)***	***t-value***	***Composite Reliability***
RVO6: The risk of suppliers acting opportunistically on product quality is considered (e.g. using a lower grade material).	0.78 (0.40)	13.881	
RVO7: We require our supplier to follow rigorous testing rules to ensure product quality and safety.	0.72 (0.48)	12.689	
RVO9: We identify potential quality and safety threats in the material we purchase.	0.65 (0.57)	11.349	
RVO11: We undertake robust testing to ensure the material received is not defective.	0.80 (0.36)	14.339	
RVO12: We evaluate the incoming inspection report to determine if there are any potential quality problems in materials	0.73 (0.46)	12.950	
RRY1: We have set up a product recall/withdrawal strategy	0.57 (0.67)	------	0.812
RRY2: We recall/withdraw the products from our customers proactively if the products are defective	0.83 (0.31)	9.562	
RRY3: If our product has a quality problem, we will unconditionally replace the defective products.	0.81 (0.35)	9.465	
RRY6: We investigate the cause of product recall/withdrawal in order to avoid it happens again.	0.65 (0.57)	8.364	

Table 5.10 Assessment of Discriminant Validity

Construct	AVE		Inter-correlation	ϕ	ϕ^2	Is Discriminat Validity supported? AVE> ϕ^2
Risk Shifting (RSF)	0.595		RSF and RSR	0.46	0.212	Yes
Risk Sharing (RSR)	0.586		RSF and RVO	0.48	0.230	Yes
Risk Avoidance (RVO)	0.549		RSF and RRY	0.29	0.084	Yes
Risk Remedy (RRY)	0.524		RSR and RVO	0.69	0.476	Yes
			RSR and RRY	0.52	0.270	Yes
			RVO and RRY	0.66	0.44	Yes

Table 5.11 Phi value in four-correlated factor model (N=289)

	RSF and RSR	RSF and RVO	RSF and RRY	RSR and RVO	RSR and RRY	RVO and RRY
Phi (ϕ) of the Four-correlated SCQRM	0.46***	0.48***	0.29***	0.69***	0.52***	0.66***
Standard error	0.284	0.304	0.249	0.371	0.320	0.384
t-value	5.265	5.680	3.60	7.306	5.493	6.466

*,**,*** *denotes Phi is significant at the p<0.05, 0.01, 0.001*

5.2.6.4 Second-order Factor Model

Figure 5.4 shows a CFA model where a second-order factor model is introduced as the cause of the four first-order factors (RSF, RSR, RVO, and RRY). It matches the Hair *et al.* (2009)'s suggestion of constructing a second-order model: a minimum of three first-order factors is needed in order to access a second-order construct. Moreover, a second-order SCQRM factor model is proposed to determine the extent of the four first-order factors' implementation (Byrne 1998).

Table 5.12 Comparison of fitness of second order factor model to four correlated model

Model	χ^2 (df)	RMSEA [90% confidence interval]	CFI	NNFI	NFI	Normed χ^2 (χ^2/df)	SRMR	PNFI
Model 3 (Four-correlated)	352.12(146)	0.070 [0.0607, 0.0794]	0.975	0.971	0.957	2.412	0.0495	0.817
Model 4 (2^{nd} order)	357.58(148)	0.070 [0.0609, 0.0794]	0.975	0.971	0.957	2.349	0.0517	0.828

As shown in Table 5.12, the establishment of a second-order factor model has an acceptable fitness, although the four-correlated factor models (model 3) and second-order factor model (model 4) have nearly the same fit measures. Moreover, Marsh and Hocevar's (1985) approach is adopted, for testing target coefficient (*T*) statistics. This is the ratio of $\chi 2$ of the first-order model (four-correlated model) to the $\chi 2$ of the higher-order model (*T= first order model $\chi 2$/ higher-order model $\chi 2$*). The target coefficient (*T*) of the second-order SCQRM model is 0.98. This indicates that the second order factor accounts for 98 percent of the relations among the 1^{st} order model. Cao and Zhang (2011) claimed that the *T* coefficient 0.80-1.00 provides support for the existence of second-order factors. Most importantly, SCQRM positively influences RSF (γ=0.52), RSR (γ=0.75), RVO (γ=0.94) and RRY (γ=0.70) (see Table 5.13). All factor loadings are significant (p-value <0.001). The implementation of four practices is really driven by the latent SCQRM.

Moreover, the monological validity is provided in the second-order factor model, since the structure links (γ) from SCQRM to the four dimensions is highly significant. More importantly, the significances of structural links in the second-

order factor model (model 4) are superior to inter-correlations in the four-correlated factor model (model 3). It can be seen from Table 5.13 and Table 5.11, that the t-values of 4 links in the second-order factor model have a higher t-value than most of the inter-correlations in the four-correlated factor model. This further supports the fact that the second-order factor model has a greater monological validity than a first-order model (four-correlated factor model).

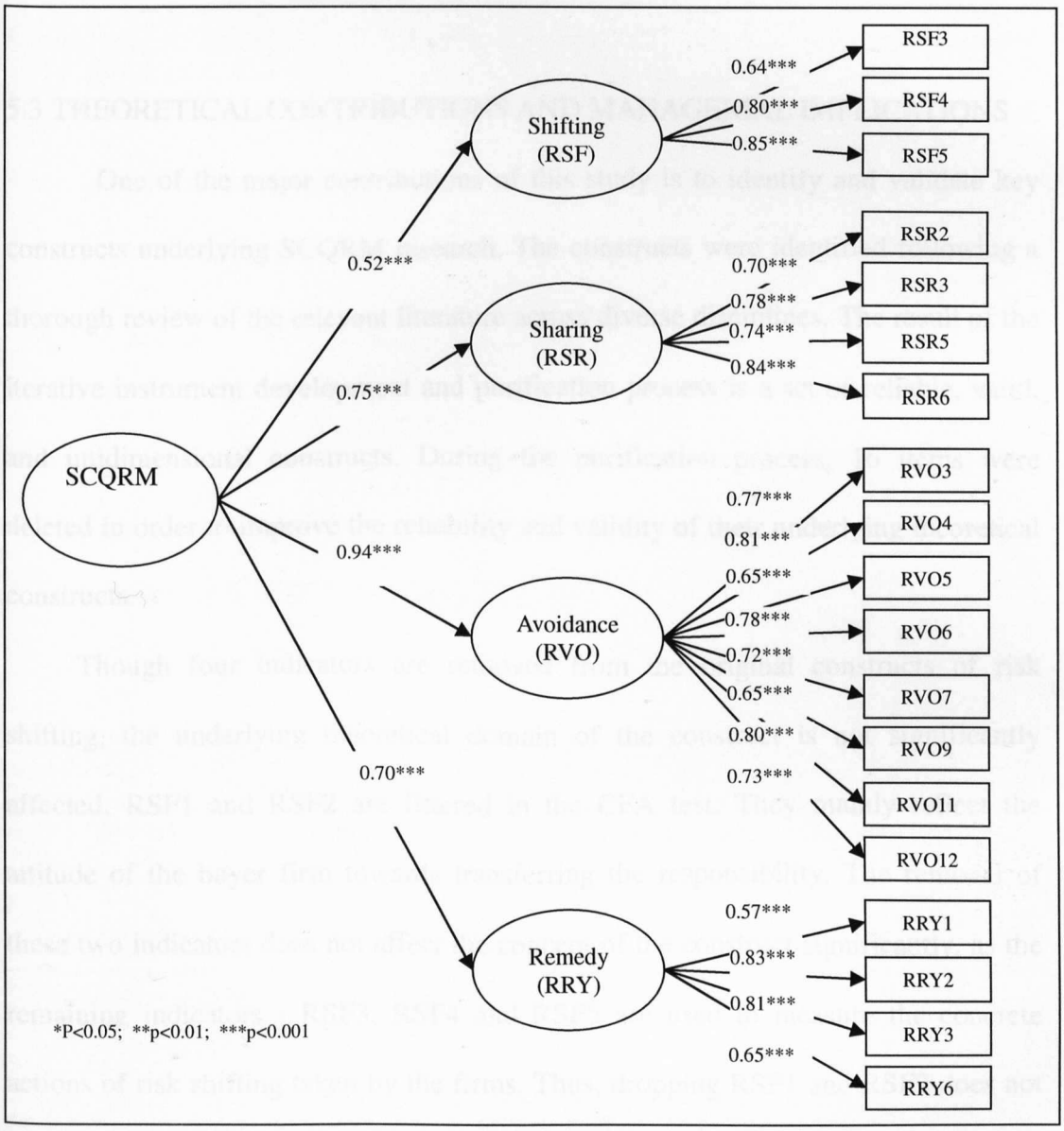

Figure 5.4 Second-order SCQRM factor model

Table 5.13 Gamma value in 2nd order factor model (N=289)

	RSF	RSR	RVO	RRY
Gamma (γ) of the 2nd order factor SCQRM	0.52***	0.75***	0.94***	0.70***
Standard error of estimate	0.133	0.146	0.152	0.160
t-value	6.753	9.723	12.788	7.868

*,**,*** *denotes Gamma is significant at the p<0.05, 0.01, 0.001*

5.3 THEORETICAL CONTRIBUTIONS AND MANAGERIAL IMPLICATIONS

One of the major contributions of this study is to identify and validate key constructs underlying SCQRM research. The constructs were identified following a thorough review of the relevant literature across diverse disciplines. The result of the iterative instrument development and purification process is a set of reliable, valid, and unidimensional constructs. During the purification process, 16 items were deleted in order to improve the reliability and validity of their underlying theoretical constructs.

Though four indicators are removed from the original constructs of risk shifting, the underlying theoretical domain of the construct is not significantly affected. RSF1 and RSF2 are filtered in the CFA test. They mainly reflect the attitude of the buyer firm towards transferring the responsibility. The removal of these two indicators does not affect the concept of the construct significantly, as the remaining indicators - RSF3, RSF4 and RSF5 are used to measure the concrete actions of risk shifting taken by the firms. Thus, dropping RSF1 and RSF2 does not significantly affect the core meaning of risk shifting. Moreover, the indicators - RSF6 and RSF7, which relate to the adoption of purchasing liability insurance, are

deleted from the final construct. They are dropped in the EFA stage. In the EFA test, RSF6 and RSF7 have been grouped as another isolated factor, so they are viewed as indicators of another concept. RSF6 and RSF7 related to the concept of transferring the loss of SCQR to the insurance company. On the other hand, RSF3, RSF4 and RSF5 relate to transferring the loss to the supplier. Although all potential indicators have the same nature of shifting the loss of SCQR to other parties, RSF6 and RSF7 have a difference in the target to which the risk is transferred. This may be the major reason why RSF6 and RSF7 are deleted in the early stage of scale development. Therefore, this construct in its present state cannot be used to study the impact of purchasing liability insurance on the adoption of risk shifting.

The risk shifting constructs generally exhibited lower reliabilities than the other constructs. Though the Cronbach's alpha value is higher than the recommended value - 0.70, it has a lower value compared with others constructs, which score over 0.84. The most plausible explanation is that respondents tend to be more knowledgeable about the other three constructs adopted in SCQRM strategies. Table 5.14 shows the result of scale development.

Table 5.14 Results of scale development in risk shifting

Item		Result
RSF1	We think that the supplier should take most of the responsibility for quality problems that are caused by the supplier, and/or even from the supplier's suppliers.	C
RSF2	Managing the quality of the material is primarily the responsibility of suppliers.	C
RSF3	For reducing the loss caused by material defects, we propose a higher penalty for the supplier.	Keep

Item		Result
RSF4	If we have any loss due to defects or have any quality problems with the sourced materials (e.g. clients' penalty, product recall, unconditional replacement), we penalize the supplier additionally by asking for compensation.	Keep
RSF5	We have laid down a detailed description of suppliers' responsibilities which will be applied if defects are found in the purchased materials.	Keep
RSF6	If our product has a high potential risk in quality and safety, we would purchase product liability insurance.	E
RSF7	We have product liability insurance to cover liability for losses or injuries to the consumer that are caused by product defects.	E

Keys used:

E = Dropped in Exploratory factor analysis (Stage 6)

C= Dropped in Confirmatory factor analysis (Stage 7)

Keep = Keep as the final measurement item

The construct of risk sharing is characterised in terms of inter-organizational collaboration to solve quality problems (RSR1, RSR2, RSR3 and RSR8), also in the effort of buyer firms to help the supplier to improve quality (RSR4 and RSR5), and in the adoption of task programmability in supplier production to control product quality (RSR6 and RSR7). Though four indicators are removed from the original constructs of risk sharing, the underlying theoretical domain of this construct is not significantly affected. Since RSR1 and RSR8 are removed from the construct, RSR2 and RSR3 still remain to represent the concept of inter-organizational collaboration. The reason for dropping RSR1 in EFA may be due to the generality of the item. It broadly measures the collaboration involved in solving problems, but is not specific to quality problems. Similarly, RSR8 only measures the early involvement of suppliers in product development, but it does not specify the idea of improving the quality. Also, RSR8 has a low variance extraction in EFA. Moreover, RSR7 does not

pass the EFA test that is related to part of the concept of task programmability. This may be due to a strong focus on process monitoring. Therefore, it is highly cross-loaded with risk avoidance. Moreover, RSR4 is dropped in the CFA test, due to a relatively high incidence of measurement error and it does not contribute in terms of discriminent validity of the construct. Table 5.15 shows the results of the examination of the proposed indicators in risk sharing.

Table 5.15 Results of scale development in risk sharing

Item		**Result**
RSR1	We regularly solve problems jointly with our key suppliers.	E
RSR2	We help our key suppliers to improve their product quality in the long run.	Keep
RSR3	We hold meetings with suppliers on a regular basis to solve quality problems.	Keep
RSR4	We invest in our key supplier's facility to improve product quality.	C
RSR5	We provide training for suppliers on quality requirements.	Keep
RSR6	We set up tasks and procedures for supplier production with our key suppliers.	Keep
RSR7	We require our key suppliers to return the documents or statistical process control (SPC) data so we can keep track of the production quality.	E
RSR8	We include key suppliers in the design stage of new products.	E

E = Dropped in Exploratory factor analysis (Stage 6)

C= Dropped in Confirmatory factor analysis (Stage 7)

Keep = Keep as the final measurement item

The construct of risk avoidance is characterised by the supplier quality

management approach which avoids selecting unreliable suppliers (RVO1, RVO2, RVO3, RVO4, RVO5 and RVO7), the identification of potential quality and safety risks in the supplier's product (RVO6, RVO8, RVO9 and RVO12), and the action of inspecting incoming material in order to stop receiving defective and unsafe products (RVO10, RVO11, RVO12 and RVO13). First of all, RVO8 is eliminated in the early purifying stage (stage 3). RVO8 seems to lack content validity in that it scores poorly in inter-judge agreement. The expert panel claimed that the meaning of RVO8 is ambiguous. It seems that it can represent the concept in two constructs, either risk sharing and risk avoidance. The retrieving of quality information from suppliers can be viewed as a cooperative activity, and the action of identifying a potential risk is a kind of preventive action. Therefore, it is suggested that RVO8 be removed since the meaning is rather ambiguous.

Moreover, four more indicators have been removed from the original construct of risk avoidance. RVO1 and RVO2 are eliminated from EFA, since they have been grouped as another new factor. RVO10 is filtered as it shares a low variance extracted in commonality to other factors. It may be due to employing a third party inspector which is another aspect of preventing risk, and it involves transferring the responsibility for reducing risk to a third party. This argument can be supported by the high cross-loading value of RVO10 to the RSF6 and RSF7 (i.e. transferring risk to third parties). Thus, further research can be conducted to explore "transferring risk to a third party" as a new construct concept by including appropriate measures (RVO10, RSF6 and RSF7) on this aspect.

Moreover, RVO13 is also eliminated due to high cross-loading on risk remedy. This may be due to the fact that robust testing in quality and safety standards is always performed after the risk issue actually occurs. Surprisingly, no item is

removed from the CFA test. This implies that the remaining items have good convergent validity and discriminant validity, compared with the rest of the three constructs. No item needs to be dropped in order to improve convergent validity and the discriminant validity of the construct. Table 5.16 shows the evaluation results of the proposed indicators in risk sharing.

Table 5.16 Results of scale development in risk avoidance

Item		Result
RVO1	We prevent suppliers from using unproven product/process technology.	E
RVO2	We rely on a small number of high quality suppliers for providing key components.	E
RVO3	Product quality and safety are the crucial requirements in our supplier selection process.	Keep
RVO4	We carry out quality audit on suppliers on a regular basis.	Keep
RVO5	We use dual or multiple supply sources for some materials.	Keep
RVO6	The risk of suppliers acting opportunistically on product quality is considered (e.g. using a lower grade material).	Keep
RVO7	We require our supplier to follow rigorous testing rules to ensure product quality and safety.	Keep
RVO8	We get quality information from suppliers to figure out potential quality problems in material.	F
RVO9	We identify potential quality and safety threats in the material we purchase.	Keep
RVO10	We employ a third party inspector for ensuring the quality of critical components we purchase.	E
RVO11	We undertake robust testing to ensure the material received is not defective.	Keep
RVO12	We evaluate the incoming inspection report to determine if there are any potential quality problems in materials.	Keep

Item		Result
RVO13	Our inspection team makes a great effort to ensure our received materials meet the international safety standard (e.g. RoHS and REACH).	E

F = Dropped as a result of Face validity assessment step (Stage 3)

E = Dropped in Exploratory factor analysis (Stage 6)

Keep = Keep as the final measurement item

The construct of risk remedy is characterised by the preparation for product recall/withdrawal (RRY1 and RRY7) and by having an attitude of being ready and willing to recall/withdraw and replace the defective products (RRY2 and RRY3), and the proper actions of managing recall/withdrawal (RRY4, RRY5 and RRY6).

The indicator RRY4 related to the prompt action in response to product recall/withdrawal is deleted from the final construct. This is because RRY4 is a reverse code item and it is highly cross-loaded to another factor in the EFA test. Therefore, this construct in its present state cannot be used to study the impact of quick response action support on the adoption of a risk remedy strategy. Moreover, RRY5 and RRY7 are dropped in the CFA test, as they have a high measurement error rate. Thus, for the sake of better discriminant validity, they have been deleted from the final construct. The high measurement error rate may be due to the unfamiliarity of the respondents of these two items. Nevertheless, this construct still represents the key theoretical domain in risk remedy. The remaining indicators denote the preparation for risk remedy actions, the appropriate action of remedy action, and the proactive and unconditional replacement of problematic products. Thus, the underlying theoretical domain of risk remedy is not significantly affected. Table 5.17 shows the result of scale development of risk remedy.

Table 5.17 Results of scale development in risk remedy

Item		Result
RRY1	We have set up a product recall/withdrawal strategy.	Keep
RRY2	We recall/withdraw the products from our customers proactively if the products are defective.	Keep
RRY3	If our product has a quality problem, we will unconditionally replace the defective products.	Keep
RRY4	We have a slow response in recalling/withdrawing defective products. (reverse code)	E
RRY5	If our product has a quality problem, we will have an unambiguous assumption of responsibility.	C
RRY6	We investigate the cause of product recall/withdrawal in order to avoid it happens again.	Keep
RRY7	Checklists are typically provided detailing the appropriate managerial actions to follow when we need to recall/withdraw a product.	C

E = Dropped in Exploratory factor analysis (Stage 6)

C= Dropped in Confirmatory factor analysis (Stage 7)

Keep = Keep as the final measurement item

In summary, all the constructs are made up of three or more items. Future research should be directed to refining these measurement items by adding new indicators to ensure that all the dimensions of SCQRM are better represented.

As noted earlier, 16 indicators were deleted from the initial measurement instrument. Though these indicators exhibited acceptable convergent validity (the composite reliability of all construct > 0.80), some of them suffer from low levels of discriminant validity. This can be explained by the relatively high measurement error rate which may be due to the unfamiliarity of the respondents with the constructs (for example, risk shifting and risk remedy). Moreover, it suggests a possibility of

overlapping in some element of the concept between the theoretical domains, such as the concepts of long-term relationships with suppliers and strategic supplier quality management; remedy plan preparation and quality and safety risk identification. Researchers should further refine and strengthen these constructs by adding new indicators that can further improve the discriminant validity between SCQRM dimensional constructs.

The contribution of scale development in this study is to provide a portrayal of a comprehensive and integrated perception of SCQRM with valid measurement scales. A multi-dimensional measure of the SCQRM construct is developed and validated, and the four dimensions derived during the empirical analysis are positively and significantly correlated with each other ($p<0.001$). Thus, it provides support for the fact that the dimensions are significantly correlated with each other and for the fact that each dimension is truly distinct from the other dimensions. The statistical and empirical results also suggest that SCQRM can be represented with four factors where each factor represents a unique facet, and also shows that SCQRM is actually a multidimensional construct. The poor model fit of one-factor model (model 1) indirectly supports this argument. Hence, conceptualising SCQRM as only a unidimensional concept may not be able to achieve content validity. Moreover, the second-order factor test further confirms SCQRM as a second-order reflective factor, and proves that SCQRM is a multi-dimensional construct. Moreover, as SCQRM is conceptualized in terms of its dimensions, it does not exist separately from its dimensions. In other words, the relationships between a multidimensional SCQRM construct and its dimension are not causal forces linking separate conceptual entities. Instead, the "superordinate" model represents associations between a general concept and the dimensions that constitute the

concept (Edwards 2001).

Firm managers should discern the close relationship between each risk management practice when the firms are planning to employ them. There is a high inter-correlation between risk avoidance and risk sharing which implies that these two practices are similar in aspect. For instance, they both are concerned with developing a relationship with trustable suppliers in order to reduce the chance of defective/unsafe materials from reaching the buyer firms. The measures scale developed in this study provides a self-evaluated checklist for firms to evaluate the level or their progress in protecting the firms from SCQR. By interpreting the result of the second-order factor model, one managerial implication is that risk avoidance has the greatest explanatory power on SCQRM, followed by sequence - risk sharing, risk remedy and risk shifting. Risk avoidance should be a major determinant of the firm's manager employing SCQRM. Thus, given limited time and resources, firms trying to gain SCQRM power should adopt risk avoidance as the first priority option. However, if firms aim to develop a comprehensive system for defending themselves from SCQR, firms should make an effort to employ these four dimensions simultaneously.

5.4 LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

This research may be hindered by several potential limitations. Firstly, most of the Chinese manufacturing firms in the Pearl River Delta are Small and Medium-sized Enterprise (SME) manufacturers. In this study, SME's are defined as that employ fewer than 200 persons (Buckley 1989). In China, SMEs make up a high percentage of the total number of firms (CPC 2012). This characteristic also has been reflected in the sample. It implies that the research findings may be biased towards

SME sized organizations.

Moreover, the measurement items involved in transferring the economic loss to an insurance company in risk shifting, are dropped in the EFA phase (i.e. RSF6 and RSF7). Thus, the risk shifting construct can only represent the concept of the firms transferring the economic loss to the upstream supply chain parties. It does not include shifting the risk to "third parties", such as insurance companies.

Finally, the development of a measurement scale for SCQRM may be limited by its strong orientation towards China manufacturers, as all the informants are from Chinese manufacturers. One important further research direction is to build up the theory related to the relationships linking SCQRM and other organizational outcomes, such as competiveness, quality performance, and firm performance. Moreover, another future study is needed in order to clear the characteristics of SCQRM, and further efforts should be made to assess the performance of SCQRM while considering various contextual factors, such as cultural factors, supply chain position, firm size, and industrial categories.

5.5 CHAPTER SUMMARY

This chapter addresses the process of scale development for SCQRM, including the steps of examining the dimensionality, reliability and validity of the scales for SCQRM. The second-order factor will be planned to validate latent variables of SCQRM which really operate the implementation of its components.

To conclude, a conceptual framework is proposed which consists of a set of comprehensive SCQRM practices for organizations to deal with SCQR. Four distinctive dimensions of SCQRM are included in the framework. The operational measures of these practices have been developed; this is the first attempt at scale

development in SCQRM practice. Robust empirical tests of all proposed item measures were conducted. The results suggest that the items are reliable and meet the established criteria for assessing validity. Finally, altogether 19 items survived after going through the 7 stages of the assessment process. The history of all removed measurement items is summarized in Table 5.14-5.17.

The proposed model forms a foundation for empirical research in SCRM, especially for reducing quality risk in the supply network. The validated measurement instruments are expected to be useful for the researchers who are interested in conducting survey research related to SCQRM. The researchers and practitioners can make use of the instruments to assess the state of risk management practice implementation, as well as for setting up hypotheses to test how these practices impact on the performance of other firms.

CHAPTER 6. THE EFFECT OF SUPPLY CHAIN QUALITY RISK MANAGEMENT ON PERFORMANCE

6.1 INTRODUCTION

In the OM and SCM literature, there is plenty of research about the adoption of risk management practices to deal with risk. Most of the researchers discuss how their proposed framework can reduce the probability and the impact of risk (Norrman and Jansson 2004, Thun and Hoenig 2011, Ritchie and Brindley 2007). Nonetheless, these studies are still limited to the relationship between the risk management "tool" and the performance of a specific operation, such as improving on-time delivery, decreasing stock, less internal interruption, reducing the bullwhip effect, supplier assurances on payment and shareholders return on shares (Thun and Hoenig 2011, Ritchie and Brindley 2007). Moreover, the results of these studies are not drawn from a large scale empirical study. As mentioned in the literature review in chapter 2, there is a lack of empirical studies related to supply chain quality risk management (SCQRM) in OM and SCM contexts. In fact, it is extremely important for the manager to understand how the SCQRM practices affect the firm's performance before they can set up proper risk management practices which match their firm's operations strategies.

In the light of this, the empirical researchers have noticed the potential value of studying the relationship between risk management and performance, and its implications. There are some recent studies assessing this kind of relationship: Zwikal and Ahn (2011) assessed the relationship between risk management tools and project successfulness in terms of project performance, cost overrun, and customer satisfaction; Mu *et al.* (2009)'s work assessed the relationship of four risk management strategies in improving new product development performance in

Chinese firms. To the best of the author's knowledge, this thesis is the first attempt at studying the effect of SCQRM practices on the firm's performance in the area of OM and SCM.

In this chapter, two models are proposed for studying the relationship between SCQRM practices and firm performance: (i) the direct effect model, and (ii) the complementarity model (see Figure 6.1). In the direct effect model, the direct effect of four SCQRM practices on the firm's performance is tested. The performance effect of each SCQRM practice is examined in isolation. Then, the complementarity model is further tested by comparing the result with that of the direct effect model. A resource based view (RBV) and the economic theory of complementarity are adopted to pinpoint the complementarity of four SCQRM practices that produce a synergy effect on the firm's performance. In other words, these four SCQRM practices are treated as complementary strategies which can mutually reinforce each other's performance (Tanriverdi and Venkatraman 2005, Milgrom and Roberts 1995).

The primary objective of this chapter is to examine the relative role of four SCQRM practices on the firm and on the quality results at the firm level. The aim of examining two models is to compare the effect on the performance of individual SCQRM practices with the effect on performance of the full SCQRM system. This comparison is widely adopted in the literature for testing whether the effect of the full system outweighs the effect of individual components or not (Venkatraman 1990, Ichniowski *et al.* 1997, Whittington *et al.* 1999, Tanriverdi and Venkatraman 2005, Mishra and Shah 2009). Thus, several research questions are addressed: (1) Does each SCQRM practice affect the quality performance (QP)? (2) Does each SCQRM practice affect the overall firm performance (FP)? (3) Is there any complementarity

effect in the SCQRM practices that affects the quality performance (QP)? (4) Is there any complementarity effect in the SCQRM practices that affects the overall performance of the firm (FP)? These questions are incorporated in the form of two conceptual models shown in Figure 6.1 and integrate them into hypotheses in this chapter.

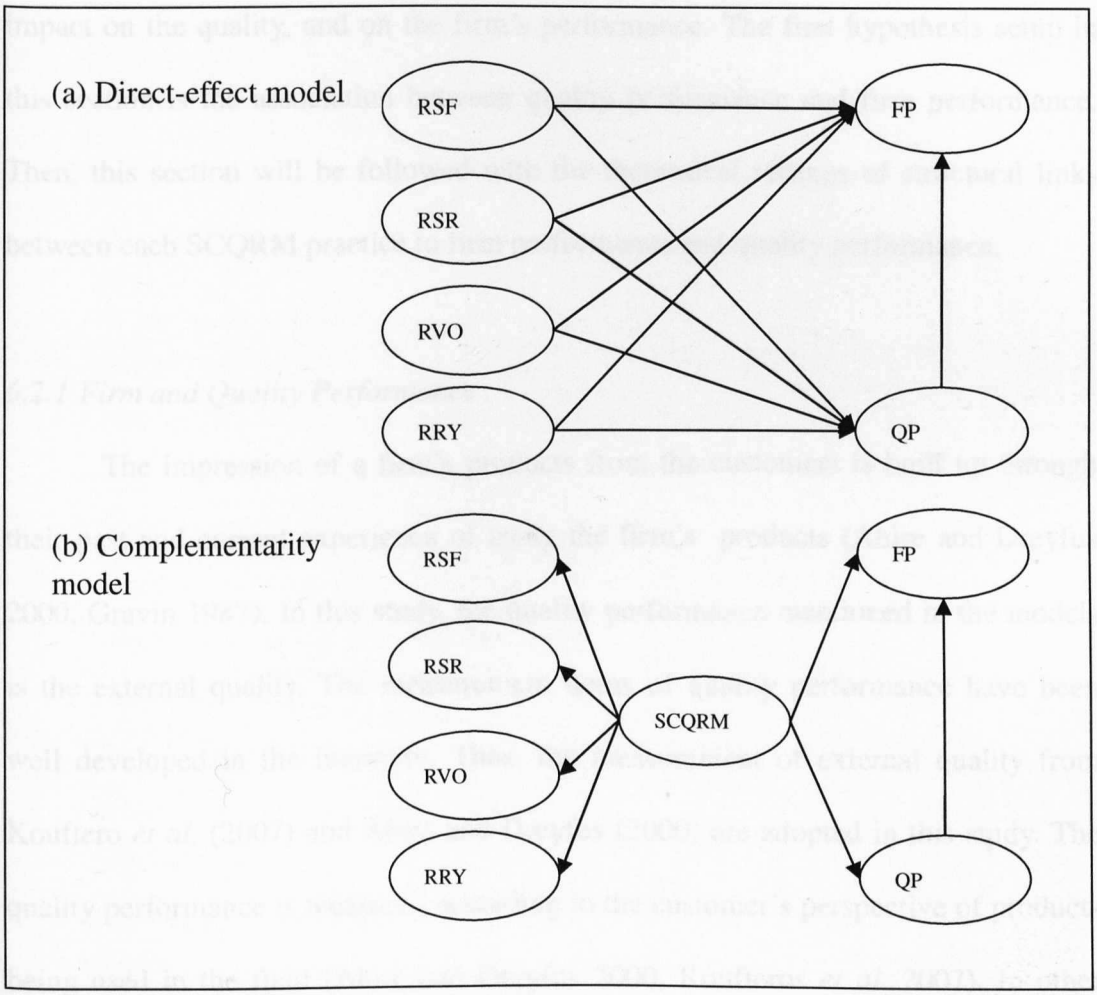

Figure 6.1 Two conceptual models of the effects of SCQRM practices on firm performance

6.2 HYPOTHESIS DEVELOPMENT OF THE DIRECT EFFECT MODEL

In this section, the theoretical development of the direct-effect model is discussed. In this model, each SCQRM practice, referred to as risk shifting (RSF), risk sharing (RSR), risk avoidance (RVO), and risk remedy (RRY), has a direct effect on quality performance (QP) and firm performance (FP). That means, when a firm applies the four SCQRM practices separately, each of them can have a positive impact on the quality, and on the firm's performance. The first hypothesis setup in this section is the association between quality performance and firm performance. Then, this section will be followed with the theoretical settings of structural links between each SCQRM practice to firm performance and quality performance.

6.2.1 Firm and Quality Performance

The impression of a firm's products from the customers is built up through their past and current experience of using the firm's products (Ahire and Dreyfus 2000, Gravin 1987). In this study, the quality performance mentioned in the models is the external quality. The measurement items of quality performance have been well developed in the literature. Thus, the measurement of external quality from Kouftero *et al.* (2007) and Ahire and Dreyfus (2000) are adopted in this study. The quality performance is measured according to the customer's perspective of products being used in the field (Ahire and Dreyfus 2000, Koufteros *et al.* 2007). In other words, the external quality of a firm is the notable difference in quality of a firm's product in the customer's eye (Murray 1988, Koufteros *et al.* 2007). Eight measurement items are used in measuring the quality performance (Ahire and Dreyfus 2000, Koufteros *et al.* 2007). The first five of them are related to the quality dimensions that most companies have taken to measure (product reliability, safety,

durability, conformance, functionality) (Koufteros *et al.* 2007). The remaining three refer to external quality failure costs (warranty work, litigation claim, customer complaint) (Juran and Gryna 1993, Ahire and Dreyfus 2000). According to Dawson and Patrickson (1991) and Ahire and Dreyfus (2000)'s works, the quality performance is measured over a three-year time frame. A 7-point Likert scale is used for the items to measure the quality performance: QP1 to QP5 have the scale of 1= decreased significantly, 4=no change, and 7= increased significantly; QP6 to QP8 have the scale of 1=strongly disagree and 7 = strongly agree. Furthermore, "three years" is a commonly used time frame for an "improvement indicator" in survey research. Table 6.1 shows the item measures of quality performance.

Table 6.1 Measurement items in quality performance

Item	Measurement items	Sample / Reference
QP1	Over the last three years, our capability of offering a reliable product that meets customer needs.	(Koufteros *et al.* 2007)
QP2	Over the last three years, our capability of offering safe-to-use products that meet customer needs.	(Koufteros *et al.* 2007)
QP3	Over the last three years, our capability of offering durable products that meet customer needs.	(Koufteros *et al.* 2007)
QP4	Over the last three years, our capability of offering quality products that meet customer expectations.	(Koufteros *et al.* 2007)
QP5	Over the last three years, our capability of offering high performance products that meet customer needs.	(Koufteros *et al.* 2007)
QP6	Over the last three years, there has been a steady decline in the number of customer complaints.	(Ahire and Dreyfus 2000)

Item	Measurement items	Sample / Reference
QP7	Over the last three years, there has been steady decline in the number of product litigation claims.	(Ahire and Dreyfus 2000)
QP8	Over the last three years, there has been a steady decline in the number of warranty claims	(Ahire and Dreyfus 2000)

For measuring the firm's performance, the measurement items developed by Kaynak and Hartley (2008) and Sila (2007) have been adopted. The respondents were asked to rate the changes in their firm s' performance during the past three years. The items cover return on investment, market share, customer loyalty, the number of successful new products introduced, and long-term profit (Sila, 2007; Kaynak and Hartley, 2008). A 7-point Likert scale is used for the items to measure the firm performance, where 1= decreased significantly, 4=no change, and 7= increased significantly [2]. Table 6.2 shows the item measures of firm performance.

Table 6.2 Measurement items in firm performance

Item	Measurement items	Sample / Reference
FP1	Return on investment	(Kaynak and Hartley, 2008)
FP2	Market share	(Sila, 2007)
FP3	Customer loyalty	(Sila, 2007)
FP4	The number of successful new product introductions.	(Sila, 2007)
FP5	Long-term profit	(Sila, 2007; Kaynak and Hartley, 2008)

Moreover, there is current literature supporting the association between quality performance and firm performance. Kaynak (2003) and Kaynak and Hartley

[2] The measurement scales of quality performance and firm performance are included in the questionnaire (Appendix 4)

(2008) claimed that the quality performance is linked to better firm performance, as the quality can increase the customer's satisfaction and enable a firm to increase price and this leads to a greater margin of profit. Therefore, we further test the following hypothesis which was proposed by Kaynak (2003) and Kaynak and Hartley (2008):

Hypothesis 1. Quality performance has a positive effect on firm performance

6.2.2 Risk Shifting and Performance

In a supply chain, it is hard for a manufacturing firm to fulfill customers' expectations of product quality without putting responsibility for quality onto its upstream suppliers (Benton and Maloni 2005, Flynn and Flynn 2005). By adopting the practice of risk shifting, the responsibility for quality assurance is pushed onto the suppliers, in terms of cost. There are various types of costs transferred to the supplier side when defects are found in the products supplied, including the cost of a defective product penalty, the cost of rework, and the cost of unconditional replacement of defective products. From another perspective, the buyer firm penalizes the supplier by requiring the supplier to compensate for the loss incurred from operational cost in managing the defective unit, and to pay the external failure cost (including the cost of warranties and repair costs) if the defective products have already been shipped to the customers. Thus, the expected unit cost of an incoming product can be lowered by the defective product penalty (Reyniers and Tapiero 1995).

By placing a high penalty on the supplier, not only is the risk and compensation cost transferred to the supplier, but also the responsibility for improving the quality of the material. A high penalty indicates a high expected cost

for the supplier to ensure the product quality, thus the buyer firm can pay less for the incoming inspection cost (Starbird 2001). To prevent the buyer firm from charging a high penalty, the supplier puts more effort in to ensuring quality by improving the standard of the quality during production and carries out a more rigorous outbound inspection (Zhu *et al.* 2007).

From the perspective of agency theory (Eisenhardt 1989, Zsidisin and Ellram 2003), risk shifting can be viewed as an outcome-based practice which can alter the objective of the supplier and make it closer to the buyer's objective. This can be achieved by increasing the penalty for defective products. Buyer and supplier can both benefit from the risk shifting practice, since the supplier will make a greater effort to get the full amount of payment with fewer penalties by ensuring the manufacturing quality, and so finally the buyer can achieve high quality products. Thus, based on this rationale, the following hypotheses are proposed:

Hypothesis 2a. Risk Shifting has a positive effect on quality performance

Hypothesis 2b. Risk Shifting has a positive effect on firm performance

6.2.3 Risk Sharing and Performance

In risk sharing, both the buyer firm and the supplier involved contribute to the overall quality of a product. The contribution consists of several activities in which the firm collaborates in improving product quality. Zhu *et al.* (2007) mentioned that quality improvement is no longer limited to operations within firms, and more firms are willing to invest in supplier quality improvement in the long run. For example, the buyer firm allocates resources to provide training for suppliers to improve supplier quality. This can be done by sending managers or professional parties, specially employed for the purpose, to provide training workshops for

suppliers.

Moreover, the buyer firm delegates to suppliers the task of producing different components and decides whether and how to share the risk arising from suppliers' mistakes in production. A template of activities necessary for the development of the product is agreed by both parties (Zsidisin and Ellram 2003, Zsidisin and Smith 2005, Eisenhardt 1989). In general, the more programmable the supplier's task is, the easier it becomes for the buyer firm to control the supplier's behaviour. If the component is fully designed by the buyer firm, it is easier to observe the supplier's product quality as information concerning the supplier's behaviour is more readily available (Camuffo *et al.* 2007).

One of the aims of creating task programmability is to reduce the target cost (Zsidisin and Ellram 2003, Zsidisin and Smith 2005). To do this, the process begins with a breakdown of allowable supplier costs. The buyer firm can provide a target cost for the supplier to aim at, in the early stage. The supplier can also suggest possible changes in the task or even in the design in order to reach the predetermined target cost. Therefore, when the firm creates the task programmability, the target cost saving is also shared with the supplier. Risk sharing can contribute to achieving a lower price and thus help the firm to remain competitive in the industry.

In addition, the risk sharing practice can contribute to improving the material quality. When the buyer firm and supplier firm are collaborating in production planning, the wastes generated in each procedure and quality variance in each task are more likely to be investigated. Thus, it is easier for both firms to take notice of suggested ways of improving the component or of cutting the cost during production (Zirpoli and Caputo 2002). Zirpolo and Caputo (2002) also pointed out that the risk sharing approach can benefit both buyer and supplier firms in terms of quality and

cost if there is a formalized procedure of profit sharing for both firms.

Therefore, the following hypotheses are proposed:

Hypothesis 2c. Risk Sharing has a positive effect on quality performance

Hypothesis 2d. Risk Sharing has a positive effect on firm performance

6.2.4 Risk Avoidance and Performance

In the literature of risk management, the risk reduction actions are often applied at a late stage in which treatment actions often are too costly and less effective, especially if the risk incidents have already happened (Adler *et al.* 1999, Norrman and Jansson 2004). Preventive activities always need to be initialized before it is too late to apply them. The major aim of risk avoidance is to prevent poor supply materials from being received and to stop these problematic materials from being incorporated into the final product. So, the actions should cover the whole material ordering procedure, including making sure (i) the supply base is trustworthy, and (ii) the inspection system is reliable. In addition, risk avoidance should be a continuous review process for ensuring the material quality is up to standard by considering SCQR in supplier selection, establishing a suitable sourcing strategy, identifying and evaluating the potential SCQR in the supply network, inspecting the materials for quality defects, and ensuring the quality of the sourced product is up to the acceptable safety standard.

Moreover, when making a decision to place an order with the suppliers, it is critical to consider the potential SCQR that is inherent in the supplier's supply network. In particular, product safety needs to be treated as an important criterion in supplier selection. Overlooking SCQR in supplier evaluation, may result in a "low

cost supplier" changing into a "high cost supplier", since the economic loss associated with product liability, product recall/withdraw, and warranty are neglected (Grackin 2008, Marucheck *et al.* 2011). Thus, a comprehensive supplier selection system can prevent an economic loss from SCQR. Moreover, the incoming inspection data can be treated as useful information in revealing and identifying potential SCQR in supplier evaluation (Tse and Tan 2011). An incoming inspection verifies conformity to specifications and provides indirect information on the supplier's quality-enhancement efforts (Hwang *et al.* 2006). Moreover, a good incoming inspection can ensure the material quality and increase production quality. In turn, other improvements in competitive factors may be experienced, such as reduced cost and fast delivery (Kaynak 2003).

In order to develop a trustworthy supply base, managers need to consider potential SCQR in the supplier's production processes. The production of high quality products necessarily relies on high quality materials. Thus, it is essential that the materials purchased meet the buyer's specifications and standards for quality and safety (Flynn *et al.* 1995, Kaynak 2003, Marucheck *et al.* 2011). The purchasing policy should emphasize the material quality rather than the price (Shin *et al.* 2000, Kaynak and Hartley 2008). Moreover, regular supplier audits and plant visits need to be conducted in order to ensure the quality performance of the supplier (Stanley and Wisner 2001, Krause *et al.* 1998). Kaynak (2003) further mentioned that the quality of purchased components is the main source of process variability, Therefore, maintaining a trustworthy supply base surely can improve quality performance.

Buyer firms need to make a great effort to manage their supply strategically, based on as few trustworthy suppliers as possible. This is one of the important elements in transaction cost minimization (Chen *et al.* 2004). Total transaction costs

are associated with the cost of negotiating, implementing, coordinating, monitoring, adjusting, enforcing and terminating exchange agreements (Carr and Pearson 1999). Yeung (2008), Liker and Choi (2004) mentioned that a better supply base management can reduce the uncertainties in buyer's firm operations, and decrease the total transaction cost, as well as opportunistic behaviour by the suppliers.

Thus, the following hypotheses are proposed:

Hypothesis 2e. Risk avoidance has a positive effect on quality performance

Hypothesis 2f. Risk avoidance has a positive effect on firm performance

6.2.5 Risk Remedy and Performance

Kumar and Schmitz (2011) claimed that ignoring the potential danger of recall/withdrawal would be pernicious to the firm's long term success. Product recall always results in the reduction of the gross profit, including the lost sales, recall operation cost, and lost inventory (Mattel 2008, Kumar and Schmitz 2011). Although we cannot claim a better remedy plan that can improve the gross profit, a better preparation for responding to the SCQR can reduce the loss of the withdrawal and recall processes. For example, a proper product recall procedure can diminish the barrier to good financial performance (Zhao *et al.* 2009, Dawar and Pillutla 2000, Heerde *et al.* 2007).

Remedial action tends to stop exacerbating the product harm crisis with regard to the supply chain partners. In other words, remedial action tries to diminish the effect of the incident by stopping the defective or unsafe products, from being delivered to downstream partners. If the focal firm can know the problem earlier, it can save the firm from a massive recall. For example, if the defective products get

only as far as the distributor, the firm only needs to withdraw the whole batch of problematic products. In contrast, when the batch of defective products has already been parcelled out and delivered to various retailers or end-customers, massive resources need to be allocated for this product recall. The operations costs of product recall includes the cost of contacting customers, logistics cost, compensation cost, the cost of penalties, or even lawsuits (Kumar and Schmitz 2011). As the defective products have passed through one more layer of downstream supply chain, the number of affected parties may increase unexpectedly. The level of seriousness of the issue depends on the nature of the product, and on the customer production lead time.

Firms with better remedy planning will be more aware of the quality issues of each component making up the product. They will know the appropriate parties (including the downstream and upstream parties) who should be contacted when defects are found following customer complaints, or from internal inspections (BRC 2007). In addition, they are more likely to ensure product quality, since they know that a massive product recall is the worst nightmare of every manufacturing firm.

Risk remedy also can be viewed as corrective action looked at from a quality management perspective. When defects are detected, appropriate action needs to be taken to stop the defects further affecting the firms. A firm needs to determine the source of the cause of a product recall/withdrawal and needs to investigate other possible suspected products that can trigger another withdrawal and recall (BRC, 2007). This is because the defective component may not be included in only a single batch of products if the defect/contamination originated from sourced material. More importantly, the firms need to scrutinize the source of the product recall/withdrawal to prevent the same incident from happening again. It is certainly a waste if the firm

needs to further correct the same quality problems twice (Willians *et al.* 2006). Moreover, during a thorough planning of remedial action, the managers can better understand which types of potential quality or safety problems of a product are most costly and hard to resolve. i.e. the product can cause a lot of *ex post* actions when it is delivered to the downstream parties, For example, when the product is contaminated by toxic substances, the contaminated products are neither reworked, nor broken down to sub-components for use in another product. The firm even needs to spend special resources for the disposal of it. Since the managers have estimated the serious consequences, they can set up an appropriate remedial plan. The manager can pay extra attention to preventing contamination from happening in the materials and final products (Kumar and Budin 2006). Thus, the related quality and safety assurance can be stimulated by the better planning of risk remedies.

Therefore, that the following hypotheses are proposed:

Hypothesis 2g. Risk remedy has a positive effect on quality performance

Hypothesis 2h. Risk remedy has a positive effect on firm performance

From the above theoretical arguments, all SCQRM practices (RSF, RSR, RVO, and RRY) have a direct effect on the firm's performance. When evaluating each type of SCQRM practice, there will be an independent direct effect on quality performance (QP), and firm performance (FP), thus the following integrated hypothesis is developed:

Hypothesis 2: Each SCQRM practice has an independent, positive direct effect on quality performance, and on the performance of the firm.

6.3 MEASUREMENT QUALITY OF VARIABLES

For testing the model, firstly, confirmatory factor analysis (CFA) is conducted to test the measurement model associated with SCQRM practices and performance measures in Lisrel 8.54. Since the four SCQRM dimensions have already been tested in chapter 5, we have further extended the CFA test to quality performance, and firm performance. In the second procedure, structural equation modeling (SEM) is employed to test the hypothesized relationship in the structural model.

In Table 6.3, the overall fitness of the Model 5 agrees with the acceptable degree of fitness suggested by Shah and Goldstein (2006). As shown in Table 6.4 and Table 6.5, all factor loadings are greater than 0.50. All the composite reliabilities are greater than 0.70, and all AVE are higher than 0.50. Based on these results, we are confident that the six constructs show acceptable convergent validity. Moreover, for assessing the discriminant validity of these six constructs, all the inter-correlation values (ϕ) in this model are less than 0.70, which means that it is unlikely that any problems will be associated with discriminant validity (Fugate *et al.* 2009, Mackenzie *et al.* 2005). Moreover, by adopting the discriminant validity test suggested by Hair (2009), Lawson *et al.* (2008), and Swink and Nair (2007), the AVE values for each pair of constructs are higher than the square of the inter-correlation between any two constructs (ϕ^2) in the model, so it can provide good evidence of discriminant validity (Fornell and Larcker 1981b). As shown in Table 6.5, all fifteen pairs of inter-correlation (ϕ^2) values are smaller than the AVE value of each construct, so it provides good evidence of discriminant validity (Fornell and Larcker 1981b).

Table 6.3 Overall fitness of the CFA model

Model	χ^2 (df)	RMSEA [90% confidence interval]	CFI	NNFI	NFI	Normed χ^2 (χ^2/df)	SRMR	PNFI
CFA model (Model 5)	1008.35 (449)	0.066 [0.0604, 0.0712]	0.966	0.963	0.94	2.246	0.0575	0.851

Table 6.4 Results of CFA in Model 5

N=289	Standardized Factor Loading λ (Error)	t-value	Composite reliability
Risk Shifting (RSF)			
RSF3	0.64 (0.59)	N/A	0.813
RSF4	0.80 (0.36)	10.479	
RSF5	0.86 (0.26)	10.569	
Risk Sharing (RSR)			
RSR2	0.70 (0.52)	N/A	0.849
RSR3	0.78 (0.39)	11.789	
RSR5	0.74 (0.45)	11.219	
RSR6	0.84 (0.30)	12.421	
Risk Avoidance(RVO)			
RVO3	0.77 (0.41)	N/A	0.953
RVO4	0.80 (0.35)	14.385	
RVO5	0.65 (0.57)	11.305	
RVO6	0.77 (0.40)	13.749	
RVO7	0.72 (0.48)	12.701	
RVO9	0.66 (0.57)	11.347	
RVO11	0.80 (0.36)	14.309	
RVO12	0.73 (0.46)	12.920	
Risk Remedy (RRY)			
RRY1	0.57 (0.67)	N/A	0.811

N=289	Standardized Factor Loading λ (Error)	t-value	Composite reliability
RRY2	0.83 (0.31)	9.575	
RRY3	0.81 (0.34)	9.490	
RRY6	0.65 (0.57)	8.389	
Firm Performance (FP)			
FP1	0.67 (0.55)	N/A	0.905
FP2	0.82 (0.32)	11.997	
FP3	0.81 (0.34)	11.897	
FP4	0.79 (0.37)	11.637	
FP5	0.79 (0.37)	11.684	
Quality Performance (QP)			
QP1	0.61 (0.62)	N/A	0.945
QP2	0.67 (0.55)	9.519	
QP3	0.78 (0.40)	10.575	
QP4	0.86 (0.26)	11.316	
QP5	0.55 (0.70)	8.122	
QP6	0.79 (0.38)	10.704	
QP7	0.71 (0.49)	9.946	
QP8	0.70 (0.51)	9.804	

Remarks: the first item in each construct is set as a reference item in CFA. Thus, no t-value can be shown

Table 6.5 Assessment of discriminant validity

Construct	AVE	Inter-correlation	ϕ	ϕ^2	Is Discriminant Validity supported? AVE> ϕ^2
Risk Shifting (RSF)	0.595	RSF and RSR	0.46	0.212	Yes
Risk Sharing (RSR)	0.586	RSF and RVO	0.48	0.230	Yes
Risk Avoidance (RVO)	0.550	RSF and RRY	0.29	0.084	Yes
Risk Remedy (RRY)	0.523	RSR and RVO	0.69	0.476	Yes
Quality Performance (QP)	0.507	RSR and RRY	0.52	0.270	Yes
Financial and market Performance (FP)	0.608	RVO and RRY	0.66	0.440	Yes
		RSF and QP	0.29	0.084	Yes
		RSF and FP	0.24	0.058	Yes
		RSR and QP	0.41	0.168	Yes
		RSR and FP	0.39	0.152	Yes
		RVO and QP	0.55	0.303	Yes
		RVO and FP	0.40	0.160	Yes
		RRY and QP	0.48	0.230	Yes
		RRY and FP	0.35	0.123	Yes
		FP and QP	0.51	0.260	Yes

6.4 DATA ANALYSIS AND RESULTS OF THE DIRECT EFFECT MODEL

In this section, SEM techniques are used to test the hypothesized causal relationships (i.e. structural links) between constructs. Table 6.6 shows the overall model fit of different measurement indices, all of them have reached the acceptable level suggested by Shah and Ward (2007) that provides a good fit for the data. Figure 6.2 and Table 6.7 summarize the structural links of the direct-effect model (model 6).

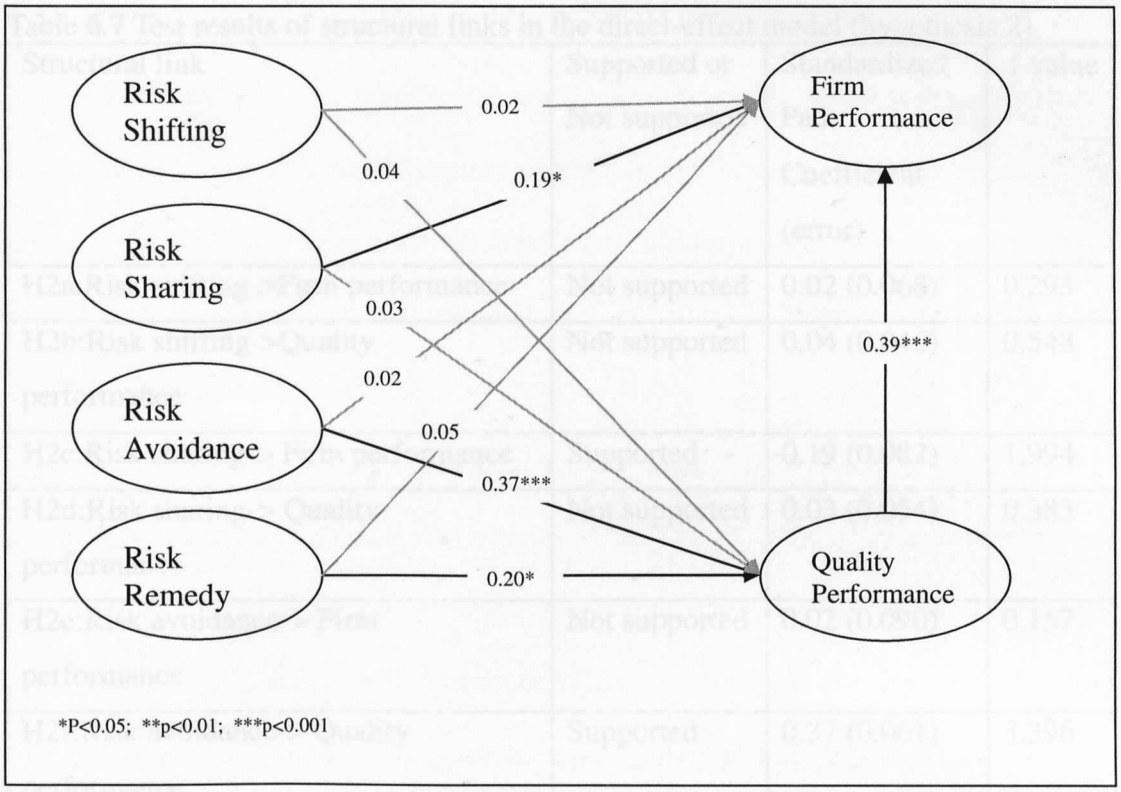

Figure 6.2 Direct-effect model (Model 6)

Table 6.6 Structural models

Model	χ^2 (df)	RMSEA [90% confidence interval]	CFI	NNFI	NFI	Normed χ^2 (χ^2/df)	SRMR	PNFI
Direct-effect model (Model 6)	1008.35 (449)	0.066 [0.0604, 0.0712]	0.966	0.963	0.940	2.245	0.0575	0.851

Table 6.7 Test results of structural links in the direct-effect model (hypothesis 2)

Structural link	Supported or Not supported	Standardized Path Coefficient (error)	t-value
H2a:Risk shifting->Firm performance	Not supported	0.02 (0.068)	0.293
H2b:Risk shifting->Quality performance	Not supported	0.04 (0.046)	0.548
H2c:Risk sharing-> Firm performance	Supported	0.19 (0.082)	1.994
H2d:Risk sharing-> Quality performance	Not supported	0.03 (0.054)	0.383
H2e:Risk avoidance-> Firm performance	Not supported	0.02 (0.090)	0.157
H2f:Risk avoidance-> Quality performance	Supported	0.37 (0.061)	3.396
H2g:Risk remedy-> Firm performance	Not supported	0.05 (0.081)	0.589
H2h:Risk remedy-> Quality performance	Supported	0.20 (0.056)	2.287

However, the standardized path coefficients of the structure links in model 6 are unsatisfactory. As illustrated in Figure 6.2, only three of the eight structural links from the four practices to performance constructs are significant. Moreover, the model shows that the structural link between risk sharing and firm performance is significant ($p<0.05$). Risk avoidance has a significant relationship with quality performance ($p<0.001$). Moreover, risk remedy has a significant relationship with quality performance ($p<0.01$).

6.5 DISCUSSION OF THE DIRECT-EFFECT MODEL RESULT

The testing of the direct effect model shows a result which is not consistent with what is reported in the literature. Only three out of eight of the structural links are supported in the data analysis. The result is surprising as there is plentiful evidence in the literature that supports the relationship between each SCQRM practice and firm performance.

Some arguments from the literature could explain why SCQRM practice does not support firm performance. For example, the insignificant relationship between risk sharing and quality performance (hypotheses 2d) can be explained by the argument in the cross-firm collaboration literature. Though the responsibility for improving quality is shared between two parties, this duty may be treated as a burden that each party would like to push onto the other. The improvement of the firm performance by risk sharing can be viewed as the reward shared between two parties when they collaborate in cost cutting in the supplier production task (Lambert *et al.* 1996). However, they only perceived a "share destiny" when they are sharing benefit, but not when sharing the responsibility for improving quality (Norek and Pohlen 2001, Lambert *et al.* 1996). This can be explained, as the payoff from cheating is always greater than the reward from fully conforming to the risk sharing agreement (Das and Teng 1998).

In the case of hypotheses 2a and 2b, the relationships between risk shifting and firm performances are not significant. It may be due to the lack of fairness criterion in the practice. Balachandran and Radhakrishana (2005) claimed that there was a fairness criterion when penalizing the supplier for supplying defective products. The penalty charged by the buyer firms should be lower than the external failure cost. i.e. the buyer firm should not benefit from external failures. Therefore,

the firm should not get the extra benefit or generate profit by penalizing the defects from supplier. Starbird (2005) further claimed that a combination of penalty and offer price motivates the supplier to improve the quality of the product, and encourages the supplier to adopt new safety technology in delivering high quality products. The supplier may only be thus motivated if the offer price is high enough to cover the amount the supplier has spent on improving the quality of the product. Moreover, by adopting risk shifting, the design and production by the supplier has been done without the knowledge of the buyer firm. i.e. the quality of the material is not observable and the buyer firm has little knowledge of the supplier's process, cost structure and materials origin (Camuffo *et al.* 2007).

As for hypothesis 2e, the analysis does not support the existence of any significant relationship between risk avoidance and firm performance. Risk avoidance may be regarded as preventive action which does not actually add value to the features of the final product. A higher level of inspection can prevent defective components from being used in the final product, but it also heightens the inspection cost and decreases the profit margin (Hsieh and Liu 2010). As for hypothesis 2g, the relationship between risk remedy and firm performance is insignificant. This can be explained in that although remedial action can reduce the loss caused by extra cost of warranty and customer compensation, the action does not add value to the product, and does not improve the profit margin (Kumar and Budin 2006, Kumar and Schmitz 2011, Heerde *et al.* 2007).

Although the insignificance of these relationships can be justified by the above arguments, the author has further investigated the limitations of model 6 – i.e. the concept of complementarity of four SCQRM practices is not captured in the model. Model 6 can only represent the direct effect of each SCQRM practice, and

only the stand-alone effect of the practice on firm performance was tested. The works of Tanriverdi and Venkatraman (2005), Mishra and Shah (2009), Menor and Roth (2008), Zhu (2004), and Wu *et al.*, (2006), provide hints on how to turn the direct-effect model into a more meaningful model. Their research stated that the second-order factor model captured the nature of complementarity of first-order factors. In other words, the presence of a second-order factor structure has an implication that the dimensions can provide a synergy effect to the outcome performance. In chapter 5, the test result of the second-order factor model (model 4) has proved the existence of a higher-order nature in SCQRM. Therefore, a second-order structure model is proposed for further study in the relationship between SCQRM and firm performance, and between SCQRM and quality performance (see Figure 6.1b). It is suggested that the unsatisfactory result in the direct effect model can be explained by *the complementarity theory*. A synergy effect exists when the four SCQRM practices are adopted in the firm simultaneously. Each of the four SCQRM practice are complementary to each other. Thus, the complemenarity model (model 7) is developed to test the relationship between SCQRM practices and the performance of the organization. The model's re-specification does not compromise the theory used in the original model. It offers a more systematic set of relationships providing a consistent and comprehensive explanation of phenomena. The way to compare two structural models can be viewed as "competing models strategy". A competing models strategy is based on comparing the established model with an alternative model through overall model comparisons. It requires two models with the same number of indicators but with different relationships portrayed for comparison. By adopting this competing models approach, the researcher attempts to test competing theories. This provides a much stronger support than testing a single

model (Hair *et al.* 2009). Thus, the competition between direct-effect model (model 6) and the complementarity model (model 7) is used to justify the existence of a complementarity effect of SCQRM impact on firm performance. The complementarity model and hypothesis development are described in the sections below.

6.6 HYPOTHESIS DEVELOPMENT OF COMPLEMENTARITY MODEL

6.6.1 Resource-based View (RBV) and Complementarity Theory lens on SCQRM

The author has adopted the theory of a *resource-based view* (RBV) and the *complementarity theory* to develop Model 7 (see Figure 6.1b). In this decade, RBV has been adopted in several OM research studies as it can provide interesting insights to clarify the strength and capability that can lead the firm to obtain sustainable competiveness (Lewis 2000, Priem and Bultler 2001). The meaning of the term "resource" is quite broad seen from an RBV perspective, in that it can be a bundle of unique materials, human, organizational resources, and skills in which the resource enables the creating of unique values. Also, resource must be difficult to imitate, and must be able to contribute to performance (Schroeder *et al.* 2002). In this research, each SCQRM practice is treated as a bundle of processes to deal with SCQR as a "resource" that is simultaneously valuable, rare, imperfectly imitable and non-substitutable. Moreover, according to the relatedness of these SCQRM practices, they can more efficiently tap into the risk management capability and generate synergies that provide a better performance. The benefits of relatedness can arise as there is a greater potential for unique combinations of resources and of capability (Benner and Veloso 2008, Hill and Hoskisson 1987). Thus, the firm can coordinate the SCQRM activities more closely.

According to Taniverdi and Vendkatraman (2005), the synergy effect can be studied through the examination of the association between resource relatedness and firm performance, when the resource relatedness can improve the firm's value. In SCQRM, the four practices share some common resources: i.e., there are joint resources when the firm operates these SCQRM activities together, so the joint operations costs are less than the sum of the stand-alone operation cost of each practice. Therefore, the resource relatedness of SCQRM practices can claim that it forms synergy which is sub-additive in operation cost (i.e. cost of (A,B) < cost of (A)+cost of (B)). Moreover, according to the theory of complementarity, the resource combination can also form a super-additive value (i.e. value (A,B) >value (A)+value(B)) to the firm (Tanriverdi and Venkatraman 2005). A set of resources can be viewed as complementary when employing more than one of them can bring in a greater return than when they are employed individually (Milgrom and Roberts 1995, Tanriverdi and Venkatraman 2005). Mishra and Shah (2009) further claims that complemetarity exists when a resource becomes more valuable in the presence of another resource, than when the resource is considered by itself . Thus, in the context of SCQRM, the process of each SCQRM practice is treated as a complementary resource that is interdependent and mutually supportive.

6.6.2 Synergies Arise from SCQRM Complemetarity

Synergies arise internally when the four SCQRM are adopted in dealing with SCQR. The four types of SCQRM practice are complementary to each other. Their co-existence can create super-additive value. For example, when considering the adoption of risk shifting to the extent that the firm needs to charge the actual amount of the penalty to the supplier, the firm needs a certain inspection level for revealing

whether the goods or materials are defective (Baiman *et al.* 2000). As the defective goods come to the firms, there is a chance that the defective goods pass through the incoming test unnoticed due to the firm's low ability to check the defects, or to an imperfect inspection policy, such as, selecting too low a percentage of samples for inspection. When the firm's ability to figure out the defective materials is relatively low, it has little deterrent effect on the supplier (Zhu *et al.* 2007, Baiman *et al.* 2000). Since the firms still accept the materials, even the supplier has no ability to deliver products that are up to standard. In other words, the supplier is not motivated to improve its quality, as the supplier is not penalized at the level that it should be. Thus, the firm with low risk avoidance also leads to low ability on risk shifting to the supplier. Risk shifting alone does not guarantee a success in shifting the economic loss.

Similarly, there is a complemenarity effect between risk sharing and shifting. These two practices are always treated as a pair of strategic actions to deal with risk (Camuffo *et al.* 2007). For example, when a firm would like to choose to accept a certain risk, the manager needs to decide how to allocate it: Is it possible to transfer the negative consequences, or can the firm attempt to absorb it? In an ideal case, risk can be totally shared by both seller and buyer parties, and the total negative consequences will be minimized with such collaboration. The effectiveness of this risk sharing is also prompted by the reward sharing linked to the risk sharing process via task programmability (such as target cost reduction). However, without a proper penalizing policy for non-conformity, suppliers may only be interested in the reward benefit, and attempt to neglect to take responsibility for quality improvement (Norek and Pohlen 2001, Lambert *et al.* 1996). Thus, risk shifting practices (i.e. penalizing non-conformity) to the supplier can be treated as a tactic to stop the supplier's

opportunistic behavior during risk sharing procedures.

When risk avoidance or risk sharing is missing, due to complementarity, the effect of one firm on another can be diminished. Risk avoidance involves strategic supplier management, and attempts to set up a reliable supply base by providing high quality materials. Without a thorough supplier rating system to select the reliable supplier, the firms cannot set up a strategic relationship with suppliers to implement risk sharing. Thus, for successful risk sharing, the firm needs a thorough appraisal system in selecting risk sharing partners (Zirpoli and Caputo 2002, Zsidisin and Smith 2005). On the other hand, if the firm only passively guards against the risk when first selecting the firm rather than proactively cooperating with the supplier to reduce the risk (i.e. risk sharing), risk avoidance also can be not very effective.

Risk remedy is also a complement to the other SCQRM practices. Without developing a precise response plan to a crisis, an ad hoc response can cause chaos all across the supply chain. Moreover, suppliers may neglect to share the risk when product recall/withdrawal is really happening. A proper remedy plan can prompt the risk sharing between the supplier and the focal firm by setting up a formalized procedure of sharing economic loss if the product recall is really necessary (Zirpoli and Caputo 2002). In addition, a remedial plan can help in deciding on what is the most reasonable amount of extra penalty to be paid by the suppliers involved, since the cost of each step of product recall/withdrawal is also estimated in the plan. Thus, the penalty charge from the risk shifting can effectively compensate for the external failure loss incurred from the product withdrawal/recall (Baiman *et al.* 2000, Tsai 1998). On the other hand, when the firm develops a remedy plan, the manager needs to know the potential quality risk in the products, and needs to establish proper procedures according to the potential impact and to the possibility of disaster

happening. Thus, the risk remedy is associated with the steps in risk avoidance.

According to Porter (1996), a firm can achieve sustainability of its corporate strategy. Competitiveness is not only gained from performing numbers of individual activities, but also from the integration of these activities. This argument also can be applied to the integration of SCQRM activities in four dimensions. The bundle of SCQRM processes acts as the resources that form unique values to a firm. Owing to the interdependence of the four SCQRM practices, the operations costs of each practice are reduced. For example, the amount spent on incoming inspections for risk avoidance is also the operation cost of determining the amount of the penalty in each risk shifting action. Moreover, the effort put into developing a trustworthy supplier base is closely linked to the effort of maintaining a long relationship with risk sharing partners. Thus, a sub-additive cost-based synergy is obtained upon the adoption of four SCQRM practices. Moreover, the complementarity of four practices forms a super-additive synergy in performance value. The bundle of SCQRM processes and skills also cannot be easy to imitate and therefore they can creates unique values, and have a strong effect on performance.

When examining the nature of the synergy effect from the sub-additive and super-additive nature of the four SCQRM dimensions, we follow the testing approach proposed by Tabriverdi and Venkatraman (2005) in which the synergy construct is captured as a latent second order factor. In this study, the first level of the latent construct captures the sub-additive operations cost synergy in four SCQRM practices. On the other hand, the super-additive value synergies arising from complementarity are captured in the second level construct.

Thus, for the evaluating the effect of the complementarity of SCQRM synergies on quality performance and firm performance, a hypothesis is proposed:

Hypothesis 3: Complementarity of SCQRM Practices has a Positive Effect on Quality, and on Firm Performance.

For proving the synergy effect of the complementaries, two opposing hypotheses are usually proposed. This method is proposed by Tabriverdi and Venkatraman (2005), and further applied by Mishra and Shah (2009). Tabriverdi and Venkatraman (2005) stated "*In assessing performance effects of a complementary system, it is imperative to compare performance effects of the full system to define the conditionality of individual effects on the effects of other system components and to ensure that the full system effects outweigh the individual effects* ". Therefore, the complementarity of the SCQRM system can be proven if hypothesis 3 shows a superior result to that of hypothesis 2.

6.7 DATA ANALYSIS AND RESULTS OF THE COMPLEMENTARITY MODEL

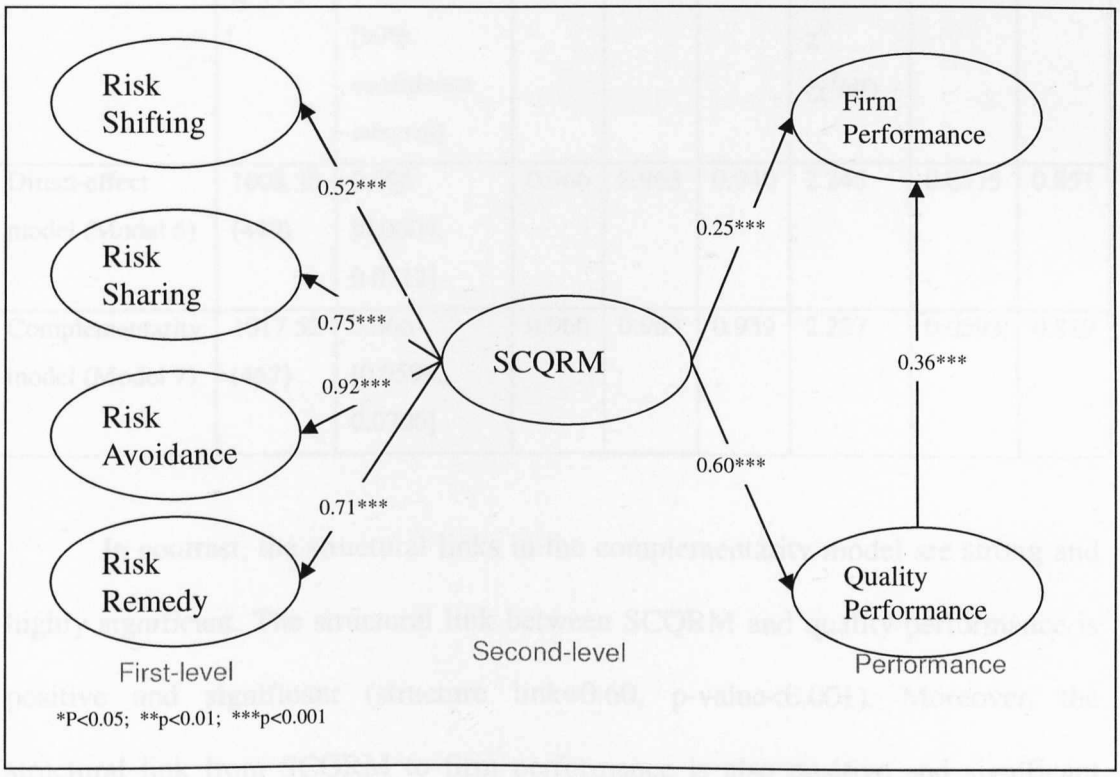

Figure 6.3 Complementarity model (Model 7)

Table 6.8 shows the fit index of two models. Both models have very similar results in model fit with the data sample. Most importantly, as described in section 6.4, only three of the eight structural links from the four practices to the performance constructs are significant in the direct-effect model. The insignificance in the structural links of the direct-effect model provides indirect support to the complementarity model (Tanriverdi and Venkatraman 2005, Mishra and Shah 2009). Thus, hypothesis 2 is not supported.

Table 6.8 Structural models

Model	χ^2 (df)	RMSEA [90% confidence interval]	CFI	NNFI	NFI	Normed χ^2 (χ^2/df)	SRMR	PNFI
Direct-effect model (Model 6)	1008.35 (449)	0.066 [0.0604, 0.0712]	0.966	0.963	0.940	2.245	0.0575	0.851
Complementarity model (Model 7)	1017.52 (457)	0.066 [0.0599, 0.0706]	0.966	0.963	0.939	2.227	0.0593	0.819

In contrast, the structural links in the complementarity model are strong and highly significant. The structural link between SCQRM and quality performance is positive and significant (structure link=0.60, p-value<0.001). Moreover, the structural link from SCQRM to firm performance is also positive and significant (structural link=0.25, p-value <0.001). These findings provide support to hypothesis 3. These indicate a second-order factor interpretation that the complementarity of four types of SCQRM practices has a positive effect on quality performance and on firm performance. Table 6.9 shows the results of structural links in the complementarity model.

Table 6.9 Test results of structural links in the complemenarity model (hypothesis 3)

Structural link	Supported or Not supported	Standardized Path Coefficient (error)	t-value
SCQRM-> Firm performance	Supported	0.25 (0.134)	3.091
SCQRM->Quality performance	Supported	0.60 (0.088)	7.764

6.7.1 Mediation Effect of Quality Performance

The above section has shown the evidence of the presence of the complementarity effect of SCQRM on performance. However, one structural link in model 7 has yet to be discussed, i.e. the structural link between quality performance (QP) and firm performance (FP).

The testing of model 7 (Figure 6.3), shows that the relationship between quality performance (QP) and firm performance (FP) is significant. The analysis result is presented in Table 6.10, and it shows support for hypothesis 1. It provides for the fact that the quality can increase the customer's satisfaction and enable a firm to raise their prices which in turn leads to a good margin of profit. Most interestingly, it has a further implication that QP can be a partial mediator between SCQRM and FP. Since the result of model 7 shows that the relationship between QP and FP (structural link=0.36, p-value <0.001) is significant, there are two possible situations: (i) partial mediating effect of QP, or (ii) no mediating effect of QP. A complete mediation cannot possibly take place as the link between SCQRM and FP is still significant (structural link=0.25, p-value <0.001) with the presence of QP (see Figure 6.3). A complete mediating effect only exists when the structural link of SCQRM and FP is insignificant with the presence of mediator QP. Figure 6.4 shows the two models which need to be tested for confirming the existence of partial mediation of the complementarity model.

Table 6.10 Test results of hypothesis 1

Structural link	Supported or Not supported	Standardized Path Coefficient (error)	t-value
Model 7: Quality performance-> Firm performance	Supported	0.36 (0.122)	4.225

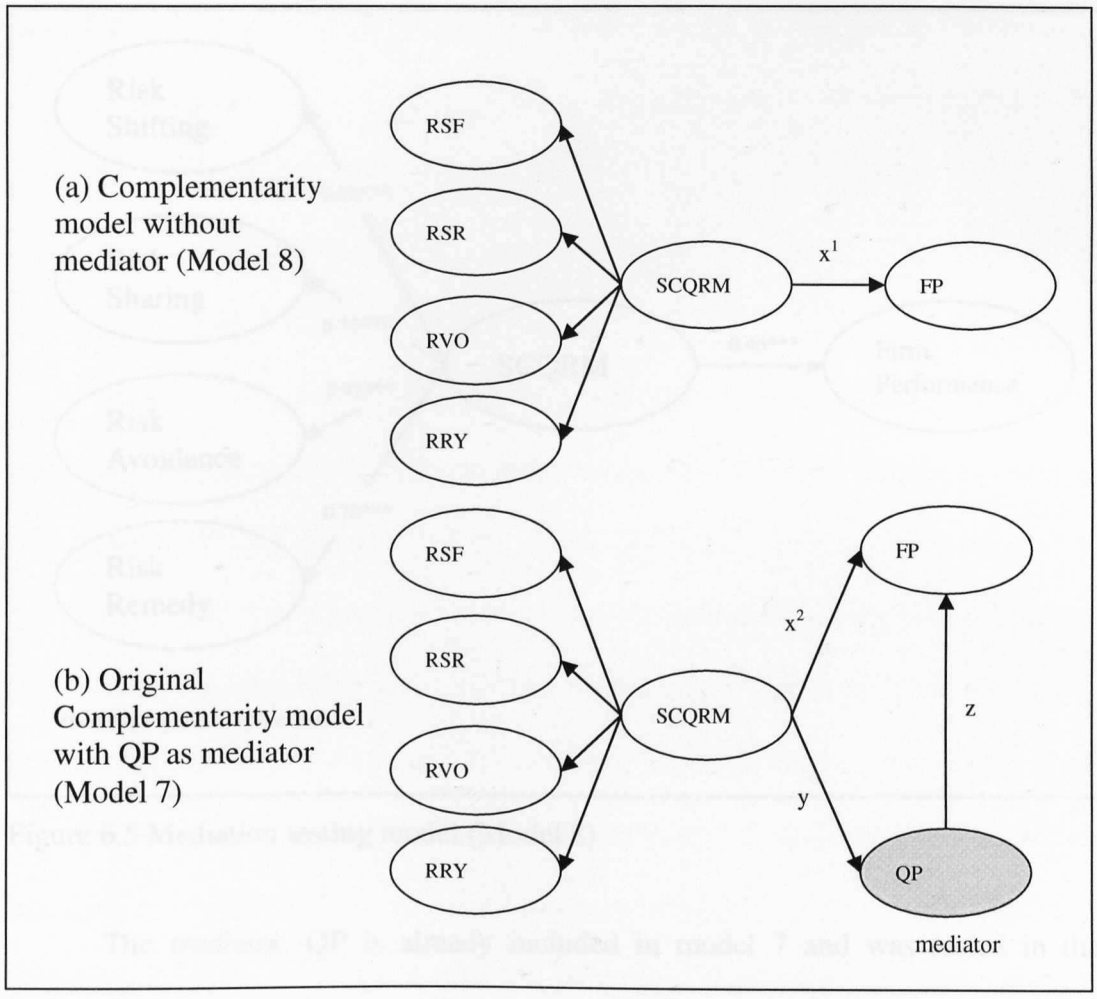

Figure 6.4 Models for testing mediating effect of quality performance

According to the mediation testing step suggested by Sarkis *et al.* (2010), a model for showing that SCQRM influences the FP (i.e. x^1) needs to be presented and shown to be significant first (as shown in Figure 6.4a). Next, another model (as shown in Figure 6.4b) with mediator is tested and the result needs to show that the relationship between the SCQRM and QP is significant (i.e. y). Third, the result needs to show the mediator variable (QP) is influencing FP (i.e. z). Finally, we need to evaluate the strength of the relationship between SCQRM and FP within two models, i.e. x^1 and x^2. Since the second step and third step in the mediation test are already done in the previous section (result of model 7), we only need to complete the first step and the final step.

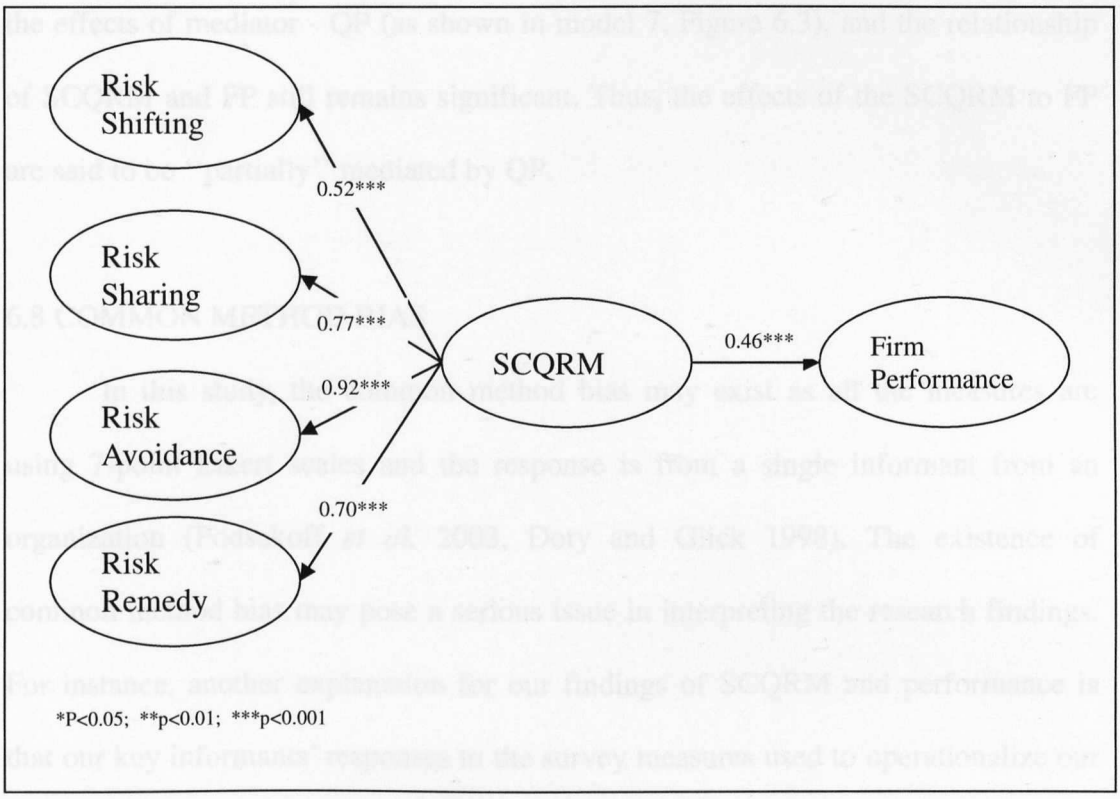

Figure 6.5 Mediation testing model (Model 8)

The mediator, QP is already included in model 7 and was tested in the previous section, thus the only thing that we need to evaluate is to test the model without the mediator. If the relationship between SCQRM and FP in model 8 does not have any difference to model 7, it means there is no mediation effect of QP. On the other hand, if the relationship between SCQRM and FP in model 8 has a stronger structural link than model 7, it indicates that there is a partial mediating effect of QP. In other words, the presence of mediator QP has decreased the strength of the relationship between SCQRM and FP. In Figure 6.5, the result of the model 8 is illustrated (without mediator). The structural link value between SCQRM and FP is 0.46 and it is highly significant at $p<0.001$.

The result of model 8 indicates that the structural link between SCQRM and FP has a strong and highly significant relationship without the presence of a mediator. Moreover, the effect of SCQRM on FP has diminished after controlling for

the effects of mediator - QP (as shown in model 7, Figure 6.3), and the relationship of SCQRM and FP still remains significant. Thus, the effects of the SCQRM to FP are said to be ''partially'' mediated by QP.

6.8 COMMON METHOD BIAS

In this study, the common method bias may exist as all the measures are using 7-point Likert scales and the response is from a single informant from an organization (Podsakoff *et al.* 2003, Doty and Glick 1998). The existence of common method bias may pose a serious issue in interpreting the research findings. For instance, another explanation for our findings of SCQRM and performance is that our key informants' responses to the survey measures used to operationalize our SCQRM dimensions and performance may reflect the size of the firm. As larger firm can have more budgets and resources allocated to SCQRM, better quality and firm performance can be achieved. To test this, the firm size is used as a predictor variable in separate ANOVAs with factor-based scores for SCQRM, quality performance, and firm performance, respectively. Our result showed that all the ANOVA *F*-values were statistically insignificant ($p>0.05$), and it provided support that the firm size was not related to key informants' perceptions used to operationalize SCQRM or performance.

Table 6.11 ANOVA test results of firm size affecting the factor-based score of SCQRM, QP and FP

	F-value (*p*)
Firm size -> SCQRM	2.328 (0.128)
Firm size -> Quality Performance (QP)	0.06 (0.937)
Firm size -> Firm Performance (FP)	3.306 (0.07)

In addition, the test of a *one-factor model* in section 4.2 also can be used to assess the possibility of existence of common method bias. As shown in Table 5.8, model 1 has a poor fit. The poor fit of the one-factor model also indicates the *common methods bias* is unlikely to be present.

6.9 THEORETICAL CONTRIBUTIONS AND MANAGERIAL IMPLICATIONS

This chapter unifies RBV and the economic theory of complementarity to conceptualize the synergy effect that arises from risk shifting, risk sharing, risk avoidance, and risk remedy in the SCQRM process. Using multi-industry and Chinese sample data from 289 firms, SCQRM practices are empirically validated in a second-order factor structure. The performance effects of four SCQRM's synergy are also assessed by using two objective measures: (i) quality performance, (ii) firm performance. The theoretical and managerial contributions of this research study are discussed below.

Theoretically, this study overcomes two main weaknesses in previous SCRM research. Firstly, the existing risk management framework majorly includes process flow in managing risk, but it is limited to showing the outcomes after a firm adopts a risk management framework. The performance measures are usually not examined after adopting SCRM strategies. This chapter has filled this gap by testing the structural links between SCQRM and performance. Since this study focuses on managing the SCQR, one of the performance measures is set as external quality performance, to assess "the notable quality differences of a firm's product in the eyes of the customer". Also, some measurement items, such as the changes in reduction of warranty works, litigation claims, customer complaints, are used in the quality performance construct. These measurement items can directly reflect the

improvement that the firm experiences on reduction of SCQR after adopting SCQRM practices, since these items always show the reduction in external quality failure cost.

Secondly, the interdependencies of SCQRM studied in this chapter, are also lacking in the previous studies. To better represent these interdependencies, the SCQRM has been conceptualized as the synergy resulting from the four key practices adopted simultaneously in handling SCQR. According to RBV, the separate involvement of risk shifting, risk sharing, risk avoidance, or risk remedy does not recognize sub-additive synergies when managing risk. On the contrary, the four practices adopted at the same time can form sub-additive synergies, as they are sharing some common resources (in the perspective of RBV, the term "resource" stands for risk management process). The firm operates these four SCQRM practices as a bundle, so the joint operations costs are less than the sum of the stand-alone operations cost of each process. Moreover, super-additive synergies of SCQRM are captured in this study. Four practices are treated as a complementary set so that employing two or more practices can increase the reward to a greater degree than using the practices individually. The use of complementarity theory in this research is an effort towards providing a more comprehensive and realistic picture of SCQRM.

The results from the two competing models prove the theoretical argument set in the theoretical development section. The superiority of the complementarity model (Model 7) to the direct effect mode (Model 6) confirms that the multiple manifestations of risk shifting, risk sharing, risk avoidance, and risk remedy are all driven by a cohesive, yet unobserved synergy, which also forms a competence to the firm.

Also, as shown in section 6.2, there are studies in the literature which support

the relationship between individual risk management practices and firm performance. However, most of these arguments in the literature lack the support of large scale empirical validation. Furthermore, in SCQRM strategy, as shown in Figure 6.2 (Model 6), conceptualising the individual dimension of a multi-dimensional construct as independent and examining the direct performance effect separately may lead to inconsistent and confusing results.

Moreover, the test results of the mediating effect of quality performance between SCQRM and firm performance shows that quality performance has a partial mediation effect on firm performance. The presence of this partial effect on quality performance gives indirect support to the existence of the complementarity effect of SCQRM on firm performance. The comparison between model 8 and model 7 shows that the effect of SCQRM on firm performance decreased from 0.46 to 0.25 after the mediator – quality performance was added. But the relationship between SCQRM and firm performance in model 7 still remained significant. This implies that part of the firm performance can be improved through quality performance, and part of firm performance is influenced by the complementarity of SCQRM. If the full mediation result is shown, then it will signify that the complementarity of SCQRM only impacts on quality performance.

This study also has important managerial implications. It suggests that managers should continue to adopt the risk shifting, risk sharing, risk avoidance, and risk remedy to achieve a superior performance. Good risk management ability can be derived when efforts are made to synchronize the capability of these four SCQRM practices. Thus, managers should continue focusing on the efficiency at the operation level of the four practices, because it constitutes the first step towards improvement of managing SCQR, so as to improve quality and firm performance.

This research reveals that the successfulness of handling SCQR is affected by a complementary set of SCQRM practices. Firms seeking to solve SCQR from the upstream supply chain should not only be concerned about individual risk management practices but should also require the complementarity of the four practices to sustain the firm being located in a lower risk position. If all SCQRM complementary practices are not adopted as a whole, the SCQRM system may not succeed because the sub-additive and super-additive value synergies are reduced. The findings suggest practitioners should exploit a complementary set of risk shifting, risk sharing, risk avoidance and risk remedy, so this unique set of SCQRM processes can create unique values which are concurrently valuable, rare, hardly imitable and non-substitutable. This bundle of risk management routines is very difficult for competitors to imitate.

6.10 LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

In this chapter, the main concern has been to detect the performance effects of SCQRM in a large, cross-sectional sample in Hong Kong and in the China-PRD region. The results here may only be limited to the China region, but they can be treated as a reference for the western firms to "read" China firms when they are motivated in forming Sino-Western alliances. An outcome approach has been adopted rather than a mechanism approach to the measurement of SCQRM. The measure of the antecedent mechanism affecting each SCQRM practice is not theorized here. Moreover, further research needs to be conducted in examining how internal and external business units coordinate using the four SCQRM practices to achieve complementarity. Also, what is the role of information sharing between supply chain partners that can leverage the four different practices? Further studies in

antecedent mechanisms may allow us to understand how firms cooperate with supply chain partners in order to enhance the SCQRM practices.

6.11 CHAPTER SUMMARY

This chapter examines the performance effect of SCQRM in Chinese firms. The adoption of risk shifting, risk sharing, risk avoidance and risk remedy can form a synergic effect on the firm's performance. It synthesizes the RBV and the economic theory of complementarity to conceptualize that these four SCQRM practices can create the sub-additive and super-additive value synergies to improve firm performance. The four SCQRM practices can mutually reinforce each other's performance outcome. In order to test the synergy effect arising from the four dimensions, we adopted the examination approach proposed by Tanriverdi and Venkatraman (2005) to test the existence of "resource complementarity" among SCQRM practices. Subsequent to Tanriverdi and Venkatraman's approach, two models are developed, a direct effect model and a complementarity model. The newly developed scales of SCQRM, described in chapter 5, were used to build up these two models. The direct effect model represents the performance effect of individual system components. On the other hand, the complementarity model represents the performance of a complementarity SCQRM system. By comparing the SEM results of these two models, it can be claimed that the full system effect outweighs the individual component effect. The direct effect model consists of three only of the eight structural links from the four practices to performance constructs, which are significant. The insignificant structural links of the direct effect model provide indirect support to the complementarity model. By contrast, all links in the complementarity model are significant. In addition, according to Tabriverdi and

Venkatraman (2005) and Mishra and Shah (2009), a synergy construct should be captured as a latent second order factor. The first level of latent constructs captures the sub-additive operations cost synergy in four SCQRM practices, and the super-additive value synergies arising from complementarity are captured in the second level construct. Therefore, on the evidence of the test results, we can conclude that the complementarity model is superior to the direct effect model and that it confirms that the multiple manifestations of risk shifting, risk sharing, risk avoidance, and risk remedy are all driven by a cohesive synergy.

CHAPTER 7. DISCUSSION AND CONCLUSION

7.1 INTRODUCTION

This chapter is structured in 6 sections in an attempt to summarise the theoretical and managerial contributions of the entire study. Each section states the major contributions of this study and links them back to the research questions. These are the research questions in this study.

- RQ1) What should SCQRM entail in order to reduce the risk to the quality of products being handled along the supply chain?
- RQ2) What would a valid measurement scale of SCQRM entail?
- RQ3) What is the impact of SCQRM on product quality and firm performance?

RQ1 is answered by proposing a comprehensive SCQRM framework in dealing with quality risk in the supply chain. Before developing SCQRM, the existing literature of SCQR and SCQRM practice are reviewed in Chapter 2. The author has proposed a SCQRM framework in Chapter 4 in which the definition and concept are defined. SCQRM is conceptualised as a multi-dimensional concept and operationalised with several elements that are representing each dimension. As the reliability and validity of the measurement scale of SCQRM dimensions need be confirmed before further analysis is being conducted, a robust scale development process is used and a final set of SCQRM dimensions are defined in Chapter 5. Moreover, the valid measurement scale of SCQRM is obtained, so RQ2 has been answered.

After the reliability and valid measurement scales are obtained, the further analysis of SCQRM impact on firm performance can be conducted. Two structural models of SCQRM-performance are developed. The relationships of SCQRM dimensions, and product quality and firm performance impact are examined. The

analysis provides a fresh perspective and understanding of SCQRM adoption. Thus, RQ3 is also answered. Table 7.1 shows the summary of the contribution of each chapter.

In this chapter, the contribution of this study is summarized; both theoretical and managerial implications of the data analysis results are mentioned. Section 7.2 discusses the contribution of the critical literature review in SCQRM. Section 7.3 discusses the contribution of the proposed conceptual framework of SCQRM. The major aims of SCQRM and the highlights of four SCQRM dimensions and their represented items are covered. In section 7.4, the implications of the measurement instruments in passing through the robust test in scale development process are discussed. Section 7.5 aims to provide an overview of SEM results of the direct-effect model and of the complementarity model. The summary of research findings generated from SEM analyses is provided. Also, the implications of the direct-effect model and the complementarity model are discussed. Research limitations and future research direction appear in the final section.

Table 7.1 Summary of contribution in this study

	Significant contribution	**Link to answer the research questions**
Chapter 2	• A systematic literature review is developed to discuss the research gap in SCQRM. • The concepts of risk, supply chain risk, supply chain quality risk, risk management, supply chain risk management, and SCQRM are clarified.	• In this chapter, fundamental support can be found for a gap in the research. This gap links all the research questions.
Chapter 3	• Research methodology adopted in this research is thoroughly discussed. The details of the analysis technique, questionnaire design, and sampling that are employed in this study are covered.	• In this chapter, the research design and how the quantitative techniques are employed in order to answer the research questions is described.
Chapter 4	• SCQRM is conceptualized as a multi-dimensional concept. A comprehensive view of managing SCQR is provided. • By consolidating the articles from the literature, four SCQRM dimensions are determined. • Numbers of measurement items are proposed to operationalise the concept of SCQRM dimensions.	• Chapter 4 aims to answer RQ1 that a comprehensive SCQRM concept is proposed. The activities and elements of each SCQRM dimension are presented, and why these dimensions are useful practices to reduce the negative consequence of SCQR is explained.
Chapter 5	• The potential measurement items of SCQRM are examined by using a series of scale development processes.	• This chapter aims to answer RQ2. The process of scale development, questionnaire design,

	Significant contribution	Link to answer the research questions
	• 19 measurement items are derived from the robust scale development process that can be claimed to be valid measurement instruments of SCQRM dimensions	and data collection is presented. After robust testing in content validity, item inter-correlation, EFA, and CFA, a valid measurement scale for SCQRM is obtained.
Chapter 6	• The performance effect of SCQRM is studied. How the SCQRM dimensions impact on the product quality, as well as the firm performance in terms of market and finance is shown. • Two major models are developed which compete with each other in testing the complementary nature of the SCQRM dimensions. By adopting SEM techniques, two models are developed and tested. The result shows that SCQRM is a complementarity system which has a synergy effect on the product quality and firm performance. The presence of synergy can be explained by looking closely at RBV and complementarity theory.	• The aim of this chapter is to scrutinize the effect of SCQRM on performance in order to answer RQ3. • Two major structural models are proposed and developed for investigating the performance effect of SCQRM. A competing model strategy is adopted to examine the performance effect of "independent SCQRM dimensions" versus the performance effect of the "complementarity SCQRM system".

7.2 DISCUSSION OF LITERATURE REVIEW OF SUPPLY CHAIN RISK MANAGEMENT

In chapter 2, various SCRM studies are reviewed, the aim of the chapter being to form a systematic literature review to discuss SCQRM. This chapter attempts to examine SCQRM from the roots of the nature of risk and of risk management (RM) to an investigation of supply chain risk (SCR) and supply chain risk management (SCRM). Selected items from the literature of supply chain risk in operations management (OM) and supply chain management (SCM) studies are discussed. It is claimed that SCQR is not only a part of SCR, but it is an initial point of a serious risk consequence as it can trigger other types of SCR, such as disruption risk, financial risk, and reputation risk. Moreover, the SCQR has a very big chance to form a domino effect across the supply chain. The definition of SCQR is further refined as the inherent quality uncertainties regarding products from the upstream supply chain, which will be propagated to downstream supply chain partners. Moreover, the drivers of SCQR are determined through the recent literature that includes two main uncertainty dimensions: the supply chain structural dimension and product design and the manufacturing dimension. The magnitude of outsourcing strategies and the complexity of global supply chains complicates the issues of SCQR. This study attempts to clarify the understanding of SCQR. The number of product recalls reveals that globalization has triggered the formation of a complex supply chain structure. More entities are involved in the supply network, leading to greater uncertainty as to the quality of the final product. Thus, quality variance is amplified across the supply chain due to the increasing level of information asymmetry among the supply chain members. Moreover, the complexity and testability of products also affect the effectiveness of quality assurance and

inspection, thereby creating catastrophic risks along the supply chain. The academics can use this unearthed information of recent product recall examples and the systematic literature review on SCQR as a basis from which to address some important elements that can drive the setting up of effective supply chain risk management strategies.

Furthermore, chapter 2 includes a thorough review of SCRM. Most of the important empirical studies of SCRM are reviewed. The empirical SCRM research mostly focuses on all kinds of SCRM, or particularly investigates disruption risk management. The product recall scandals in these few years have aroused considerable research interest in SCQRM. Academics have started to scrutinize SCQR and effective ways to manage its negative impact (Gray *et al.* 2011, Hora *et al.* 2011, Marucheck *et al.* 2011). This review has provided a holistic view of recent SCQRM research. Also, the research gaps in the SCQRM area have been determined, including the lack of a comprehensive model for coping with SCQR both upstream and downstream, lack of empirical research in investigating the relationship between SCQRM and firm performance, and the lack of large scale empirical research in SCQRM. This literature review and the research gap identification of SCQRM in this chapter can provide an overview of the research and some new insights to academics starting new empirical research in SCQRM.

7.3 DISCUSSION OF THE CONCEPTUAL CONTRIBUTION OF THE SCQRM FRAMEWORK

In chapter 4, the conceptualization and operationalization of SCQRM is discussed. The major contribution of this chapter is to advance the current knowledge of SCRM and develop a comprehensive view of SCQRM by integrating

the perspectives of SCM and RM.

In the literature, scholars mostly focused on some specific practices in reducing risk. For example, recall management to reduce the negative consequence (Kumar and Budin 2006, Kumar and Schmitz 2011, Hora *et al.* 2011); supply chain quality management to enhance supplier product quality (Kaynak and Hartley 2008, Yeung 2008, Foster 2008).

However, there is a lack of an overview from the RM perspective to solve SCQR problems. In this study, we propose SCQRM as a multi-dimensional construct that provides a holistic representation of complex risk management practices. Referring to the definition of a multi-dimensional model from Edwards (2001), SCQRM can be viewed as a "superordinate construct" since it represents a general concept that is manifested by specific dimensions. Moreover, Edwards (2001) stated that a multi-dimensional construct can allow researchers to match the broad predictors with broad outcomes. Thus, conceptualization of a multi-dimensional SCQRM concept can benefit researchers who wish to study the relationships of diverse outcomes. Just like many other SCRM studies (Lewis 2003, Jüttner *et al.* 2003, Tang 2008), SCQRM is conceptualized as a multi-dimensional concept which consists of four dimensions: risk shifting, risk sharing, risk avoidance and risk remedy. Moreover, SCQRM is a multidimensional construct which is conceptualized in terms of its dimensions. In other words, the concept of SCQRM itself does not exist if it is considered separately from its dimensions. Edward (2001) claimed that "*the relationship between the multi-dimensional construct and its dimensions are not causal forces linking separate conceptual entities, but instead represent associations between a general concept and the dimensions that represent or constitute the construct*". Therefore, in this study, SCQRM is conceptualized as a general concept

which is represented by four dimensions. Also, operationalisation takes place only in these four dimensions, but no specific item is tapped into the second-order SCQRM construct. This is because the four dimensions are treated as the indicators of the SCQRM model. Thus, the observed variables of the dimensions are the indicators of the dimensions, and the dimensions themselves are treated as the indicators of the SCQRM construct (see figure 4.5).

The four SCQRM dimensions can be grouped into two categories, i.e. prevent-react and risk allocation. The prevent-react group involves *ex ante* and *ex post* action in which both of them aim to reduce the probability and impact of SCQR. Risk avoidance is an *ex ante* as it can reduce SCQR from upstream before it brings negative consequences to the firm; risk remedy is an *ex post practice* as it can reduce the negative consequences that SCQR inevitably brings. The other group – risk allocation consists of risk shifting and risk sharing. In the literature, the importance of risk allocation may have been overlooked since the major stream of SCRM studies focused on risk avoidance. Although Camuffo, *et al.* (2008)'s study stressed the importance of risk allocation, it was still limited to supply chain disruption risk. The conceptualization of SCQRM has bridged the research gap of risk allocation in quality risk. Both risk shifting and risk sharing are conceptualized with the main focus on agency theory. Risk shifting is an outcome-based practice which focuses only on outcome. It can be achieved by including a proper penalty clause for the supplier. On the other hand, risk sharing is a behaviour-based practice which aims to control the supplier's behavior and reduce supplier's opportunism. It can be achieved by employing task programmability in supplier production so as to monitor the supplier quality control effort.

Moreover, the four dimensions have been operationalised into sets of

potential measurement items which represent their constructs. The reliability and validity of the items are rigorously tested in chapter 5. Moreover, the operationalisation of SCQRM has broadened the traditional measures rooted in SCRM. The citations and the justifications of the measurement items are listed in Appendix 1.

7.4 DISCUSSION OF SCALE DEVELOPMENT OF SCQRM

In chapter 5, the development of a comprehensive scale provides a SCQRM with valid measurement scales. This study illustrates that four dimensions should be considered as SCQRM dimensions. A multi-dimensional measures of SCQRM that includes risk shifting, risk sharing, risk avoidance, and risk remedy, are developed and validated. These four factors, derived during the empirical analysis, are positively and significantly correlated with each other ($p<0.001$). The statistical and empirical results associated with the CFA model suggest that SCQRM can be represented by four factors where each factor represents a unique facet, and also show that SCQRM is actually a multidimensional construct. In other words, framing SCQRM as a single factor or a unidimensional concept may not result in scale validation.

Managers should note the close relationship between all the risk management practices when the firms are planning to employ them. In addition, there is a high inter-correlation value between risk avoidance and risk sharing ($\phi = 0.69$). This may be due to the fact that these two practices aim to reduce the chance of defective/unsafe materials from reaching the buyer firms. Risk avoidance involves internal preventive action, such as identifying potential quality problem/risk via supplier evaluation and via internal inspection. Risk sharing consists of proactive

action related to supplier cooperation with the aim of working together to improve quality. Both risk sharing and risk avoidance are of a "preventive nature". In addition, from the four SCQRM practices examined in the second order factor model, risk avoidance has the greatest explanatory power regarding SCQRM, so risk avoidance should be a major determinant of the firm's decision to employ SCQRM. In summary, the CFA results suggest that a well-developed SCQRM will include all four practices. Moreover, the second-order factor analysis provides a support to the multi-dimensional and integrated nature of SCQRM the aim of which is to reduce quality risk in the supply chain. Thus, it is suggested that firms make an effort to employ these four dimensions simultaneously to achieve a set of comprehensive risk management strategies to protect the firms from devastating risk events. Moreover, the scale developed here can be used as a self-evaluating checklist for the practitioners to evaluate their progress in protecting the firms from product harm.

7.5 DISCUSSION OF SCQRM IMPACT ON FIRM PERFORMANCE

Apart from developing a valid scale for SCQRM, another major contribution of this study is the investigation of the performance effect of SCQRM. Two critical structural models are developed and tested in this study. These two models are based on a "competing models strategy" which compares the established model with an alternative model through overall model comparisons, including overall fitness, and structural links. It also requires the two models to have the same number of indicators but with different relationships portrayed for comparison.

The first model is a simple direct-effect model in which the individual dimension impacts on product quality, and firm performance is assessed. The second model is a complemetarity model, the multi-dimensional nature of SCQRM of which

is captured in the developed model. Edwards (2001)'s work of distinguished different multi-dimensional construct is relevant to the structure of the complementarity model (Model 7) in this study which is classified as a "superordinated cause model" in which the SCQRM is a "superordinate construct" that has an impact on the performance.

For measuring the performance of SCQRM, it may be best to view how SCQRM reduces the risk level. However, this study does not directly measure the impact of SCQRM on risk. The major reason is that the concept of SCQR is hard to quantify. Moreover, there is no universal definition of risk. Thus, the concept of risk may be ambiguous to the respondents, as they may have different definitions of risk. Thus, for operationalising risk into a question item may lead to confusion in the analysis results. Also, it is difficult to collect the perception of SCQR from the informants since it is a kind of sensitive question that may prevent the respondents from completing the questionnaire. In addition, the question item of measuring the number of product recalls may not be suitable for inclusion in the survey, as the expert panel in content validity test advises that the information directly related to product recall is also sensitive so that most of the respondents may not be willing to disclose such information, and it may lower the response rate. That is also the reason why most of the literature in product recall management is only based on secondary data (Hora *et al.* 2011, Thirumalai and Sinha 2011, Zhao *et al.* 2009).

In this research, the measurement of the quality performance construct includes the question items to measure the effect of SCQRM of the product quality. More importantly, the external failure of a product is also included in the quality performance construct. The external failure of products with regards to the amount of warranty works, the number of litigation claims, customer complaints in the

company, can be used instead of measuring the number of product recalls/withdrawals.

The direct-effect model aims to test the performance effect of individual SCQRM system components. On the other hand, the aim of the complementarity model is to assess the full SCQRM system effect. RBV theory and complementarity theory are unified to conceptualise the synergy effect that arises from risk shifting, risk sharing, risk avoidance, and risk remedy in the SCQRM process. The competing result shows the complementarity model has a superior performance compare to the direct-effect model. This result supports the existence of synergy when four key dimensions are adopted simultaneously in handling quality risk. On the other hand, as shown in the analysis result of model 6, separately employing four SCQRM dimensions does not achieve the desired outcome which is to protect product quality and improve firm performance.

In contrast, the four practices adopted at the same time can form sub-additive synergies, as they are sharing some common resources. Refer to RBV, the processes of effective SCQRM are viewed as a firm's resource and are operated as a bundle, so the combined operation costs are less than the sum of standalone operations. Moreover, according to complementarity theory, four practices are treated as a complementary set because employing four practices together (super-additive synergies) can increase the product quality and firm performance more than when they are applied individually. Moreover, a partial mediating effect of quality performance between SCQRM and firm performance has provided extra evidence of the existence of synergy on firm performance.

This research finding provides interesting insights into SCQRM implementation to firm managers. Managers are advised to adopt the risk shifting,

risk sharing, risk avoidance, and risk remedy simultaneously to achieve a superior performance. The managers should continue focusing on the efficiency at the operational level of four SCQRM practices, as this constitutes a large step towards improvement of product quality and firm performance. Figure 7.1 shows the illustration of the complementarity model. The key elements of each SCQRM dimension are also listed in the Figure 7.1. These key elements are the summary of the core activities of four dimensions which have been validated in chapter 5. As shown in the figure, the sub-additive synergy effect exists between the SCQRM complementarity system and firm performance, as the joint operation cost approach of four dimensions saves the firm's resources and improves the financial performance. However, saving operations cost and sharing joint resource should not have any influence on product quality. Furthermore, the super-additive synergy effect is present between SCQRM and quality performance, and between SCQRM and firm performance, as the activities of four SCQRM dimensions are interrelated and they forms a bundle of SCQRM activities/routines which can successfully reduce SCQR, improve product quality and firm performance (the support arguments are presented in section 6.2.2). In summary, the research findings suggest the managers should employ a complementary set of risk shifting, risk sharing, risk avoidance and risk remedy. Regarding RBV, this unique set of SCQRM processes can create unique values for the firm, and these resources are concurrently valuable, rare, hard to imitate and non-substitutable.

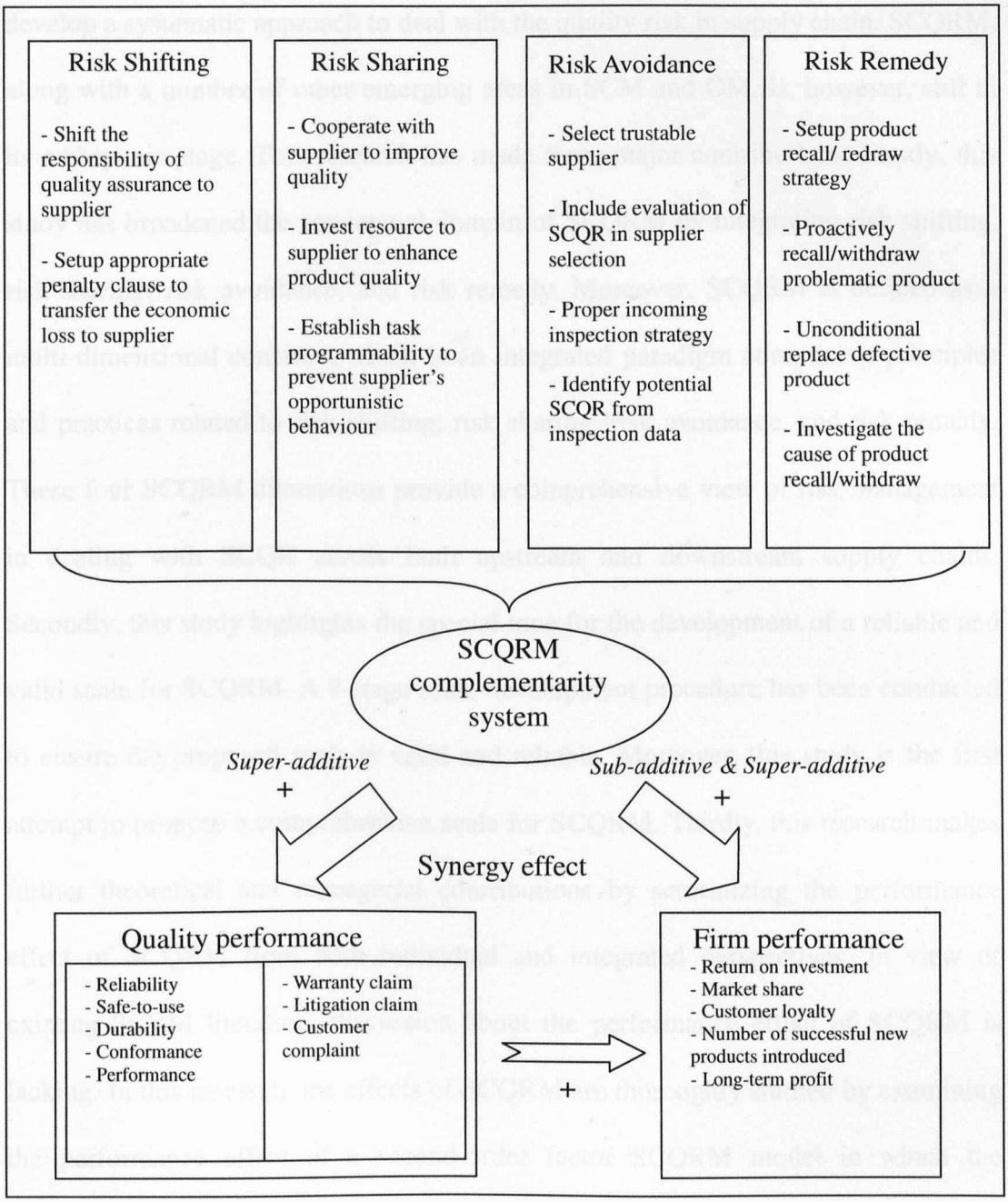

Figure 7.1 Illustration of SCQRM complementarity system impacts on performance

7.6 CONCLUSION, LIMITATIONS AND SUGGESTIONS FOR FUTURE RESEARCH

SCQRM is one of the most discussed and popular topics recently addressed in both academic and industrial areas. The rapid rise of the number of product recall cases has become the wake-up call to industrialists warning them that they need to

develop a systematic approach to deal with the quality risk in supply chain. SCQRM, along with a number of other emerging areas in SCM and OM, is, however, still in its embryonic stage. This research has made three major contributions. Firstly, this study has broadened the conceptual domain of SCQRM by integrating risk shifting, risk sharing, risk avoidance, and risk remedy. Moreover, SCQRM is defined as a multi-dimensional construct which is an integrated paradigm comprising principles and practices related to risk shifting, risk sharing, risk avoidance, and risk remedy. These four SCQRM dimensions provide a comprehensive view of risk management in dealing with SCQR across both upstream and downstream supply chains. Secondly, this study highlights the special tone for the development of a reliable and valid scale for SCQRM. A 7-stage scale development procedure has been conducted to ensure the proposed scale is valid and reliable. Moreover, this study is the first attempt to propose a comprehensive scale for SCQRM. Thirdly, this research makes further theoretical and managerial contributions by scrutinizing the performance effect of SCQRM from both individual and integrated perspectives. In view of existing SCRM literature, discussion about the performance effect of SCQRM is lacking. In this research, the effects of SCQRM are thoroughly studied by examining the performance effect of a second-order factor SCQRM model in which the correlations between SCQRM dimensions are fully captured. The analysis result testifies to the existence of complementarity among SCQRM dimensions. Also, the SCQRM second-order factor is positively associated with product quality and firm performance. Moreover, this research has further demonstrated that the complementarity SCQRM system exerts a stronger effect on performance than individual SCQRM dimensions do.

In addition, the definition of SCQRM includes both risk allocation practices,

reactive and preventive practices. In this sense, the central objective of SCQRM is to reduce the impact and possibility of SCQR. The conceptualization is quite broad in that it can precisely fit into a variety of applications. Thus, this research focuses on the adoption of SCQRM in a single firm as the unit of analysis. Future researchers should be aware that the unit of analysis may change if they only take one of the dimensions in SCQRM to scrutinize in their future research. For instance, if only risk shifting or risk sharing is investigated, then the unit of analysis will be changed to "dyadic relationship between manufacturing firm and supplier". In contrast, the unit of analysis may change to a dyadic relationship between manufacturing firm and customer, if only risk remedy is taken as the construct in the study.

7.6.1 Limitations and Future Research

While this study has made significant contributions to academic and industrial areas, there are limitations that need to be considered when interpreting the research findings.

Though the SCQRM measurement instrument developed in chapter 5 has gone through a robust 7-stage procedure, a re-validation is suggested for further enhancing the generalization of the concept domain. There are various ways to re-validate measurement instruments, including a multiple-informants approach, and a second-rater approach.

In this research, only a single key respondent is used for collecting the data. However, the use of a single respondent's approach to rate a diverse topic of supply chain-related question items may generate some inaccuracy and more than the usual amount of random error (Cao and Zhang 2011). Future research should seek to utilize multiple respondents in each participating organization in order to improve the accuracy and to reduce the random error. However, it is very difficult to receive

multiple informants in the same organization.

Another possible approach to offset the single informant concerns is the second-rater approach. This can be done by requesting the respondent to re-rate the questionnaire items. Shah and Ward (2007) suggested collecting around 10% of second-rater samples to evaluate the inter-rater reliability and inter-rater agreement in order to re-validate the developed measurement instruments. Thus, either multiple respondents or the second-rater approach can be adopted to further validate the developed SCQRM measurement in this research.

Moreover, the same sample data is used to purify and validate our measures in chapter 5, and also test the hypotheses in chapter 6. The difficulty in data collection is obtaining a large enough sample to allow splitting the data into two lots of samples for conducting scaled development and hypothesis testing. This difficulty has led several scholars to make a compromise (Krause 1999, Narasimhan and Das 1999, Swafford *et al.* 2006, Cao and Zhang 2011).

The findings of this research may be limited to the area of Hong Kong and Pearl River Delta Region in China. Thus, it is possible to further generalize the findings of the SCQRM study to a greater population, and collect a larger sample size. A large and mixed population of respondents from multiple sources is suggested. Future research should also include a larger data sample to conduct a multi-group analysis to examine the moderating effect of different firm size to SCQRM practices.

Moreover, as mentioned in chapter 6, a successful SCQRM results from building complementarity power in a bundle of risk management resources and routines. Although the four-correlated factor model indicates the four SCQRM dimensions are significantly associated with each other, little is known about the sequence to implement them. In future research, researcher should investigate the

implementation sequence and examine the strength between any two SCQRM dimensions and investigate which pairs of dimensions should be better to implement together in order to achieve the desired outcomes.

In this study, an outcome approach has been adopted in investigating SCQRM, but the antecedent mechanism of SCQRM is not yet known. Thus, it will be fruitful to study the antecedent mechanism affecting SCQRM in the future research. For example, examining how internal and external business units coordinate using the four SCQRM practices to achieve complementarity. Also, what is the role of organizational controls, such as social control and formal control, between supply chain partners that can impact on SCQRM system? Further studies in antecedent mechanisms may allow us to understand how firms interact with supply chain partners in order to enhance the SCQRM practices.

Moreover, case studies can be conducted to validate the empirical findings in this study. Case study based research can be a very useful tool to explain "how" or "why" complementarity phenomena existed in SCQRM. For example, case studies can be conducted for generating deeper insights of each SCQRM practice, and investigating the implementation problems by drawing from interview evidence, which is potentially supporting of the primary data collection. Also, case studies can be adopted for scrutinizing the interaction mechanism among SCQRM complementary that can enhance product quality and firm performance.

In summary, this study has focused exclusively on conceptualising SCQRM, scale development and testing its performance effects in the firm. Based on the synthesis among the research findings and the new insights from this study, academics and practitioners can refer to this study to develop their own SCQRM framework. Alternatively, researchers can assess how additional factors may affect

SCQRM practices by applying current constructs within different operational contexts. In short, the proposed SCQRM model provides a basis for the further development of in both quantitative and qualitative empirical works, relating to the context of SCRM.

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APPENDIX 1 – DESCRIPTION OF MEASUREMENT ITEMS IN SCQRM DIMENSIONS

Key:

#: question item amended from existing items in literature

∗: question item borrowed from existing literature, but it represents another concept/construct

Newly added: question item generated in this study by referring the concept from related literature

RISK SHIFTING

Table A1.1 Measurement items in risk shifting

Item	Measurement items	Reference	Description
RSF1	We think that the supplier should take most of the responsibility for quality problems that are caused by the supplier, and/or even from the supplier's suppliers.	(Camuffo *et al.* 2007)	Newly added
RSF2	Managing the quality of the material is primarily the responsibility of suppliers.	(Zsidisin *et al.* 2006)	# Amend from Zsidisin's work to fit the context of SCQRM
RSF3	For reducing the loss caused by material defects, we propose a higher penalty to supplier.	(Balachandran and Radhakrishnan 2005, Starbird 2001, Starbird 2005)	Newly added
RSF4	If we have any loss due to defects or have any quality problems with the sourced materials (e.g. clients' penalty, product recall, unconditional replacement), we penalize the supplier additionally by asking for compensation.	(Baiman *et al.* 2000)	Newly added
RSF5	We have laid down a detailed description of suppliers' responsibilities which will be applied if defects are found in the purchased materials.	(Hwang *et al.* 2006, Camuffo *et al.* 2007)	Newly added
RSF6	If our product has a high potential risk in quality and safety, we would purchase product liability insurance.	(Berenson 1972a, Ritchie and Brindley 2007)	Newly added
RSF7	We have product liability insurance to cover liability for losses or injuries to the consumer that are caused by product defects.	(Berenson 1972a, Ritchie and Brindley 2007)	Newly added

RISK SHARING

Table A1.2 Measurement items in risk sharing

Item	Measurement items	Reference	
RSR1	We regularly solve problems jointly with our key suppliers.	(Li *et al.* 2006)	∗Refer to Li *et al.*, (2006) work, the measurement is considered as the item of ***strategic supplier partnership*** in SCM practices
RSR2	We help our key suppliers to improve their product quality in the long run.	(Li *et al.* 2006)	∗Refer to Li *et al.*, (2006) work, the measurement is considered as the item of ***strategic supplier partnership*** in SCM practices
RSR3	We hold meetings with suppliers on a regular basis to solve quality problems.	(Stanley and Wisner 2001)	∗Refer to Standley and Wisner (2001), this item is treated as measurement instrument of ***cooperative purchasing /supplier relationship***
RSR4	We invest in our key supplier's facility to improve product quality.	(Baiman *et al.* 2000, Zhu *et al.* 2007)	Newly added
RSR5	We provide training for suppliers on quality requirements.	(Stanley and Wisner 2001)	∗Refer to Standley and Wisner (2001), this item is treated as measurement instrument of ***cooperative purchasing /supplier relationship***
RSR6	We setup tasks and procedures for supplier production with our key suppliers.	(Camuffo *et al.* 2007, Lyles *et al.* 2008, Zsidisin and Ellram 2003)	Newly added
RSR7	We require our key suppliers to return the documents or statistical	(Rungtusanatham *et al.* 1999, Lyles	#The idea of returning back the

Item	Measurement items	Reference	
	process control (SPC) data so we can keep track of the production quality.	*et al.* 2008, Kaynak and Hartley 2008)	document is originated from Lyles 2008, also it is inspired by Rungtusanatham *et al.*, (1999)'s work for obtaining ***SPC data*** and Kaynak and Hartley (2008) for ***quality data and report***
RSR8	We include key suppliers in the design stage of new products.	(Stanley and Wisner 2001)	∗Refer to Standley and Wisner (2001), this item is treated as measurement instrument of ***cooperative purchasing /supplier relationship***

RISK AVOIDANCE

Table A1.3 Measurement items in risk avoidance

Item	Measurement items	Source / Reference	Description
RVO1	We prevent suppliers from using unproven product/process technology.	(Zsidisin *et al.* 2006)	# Amend from Zsidisin's work to fit the context of SCQRM
RVO2	We rely on a small number of high quality suppliers for providing key components.	(Shin *et al.* 2000)	* Refer to Shin *et al.* (2000), this item is treated as measurement instrument of ***buyer-supplier management***
RVO3	Product quality and safety are the crucial requirements in our supplier selection process.	(Kaynak and Hartley 2008, Shin *et al.* 2000, Marucheck *et al.* 2011)	# The idea is gotten from the supplier selection consideration in Kaynak *et al.*, (2008) – ***supplier quality management*** and Shin *et al.* (2000) - ***buyer-supplier management***, and add the context of product quality and safety from Marucheck *et al.* (2011)'s research
RVO4	We carry out quality audit on suppliers on a regular basis.	(Stanley and Wisner 2001)	# The idea is gotten from the items from Stanlsy and Wisner (2001) about "periodic audit of supplier facilities" in ***cooperative purchasing /supplier relationship***
RVO5	We use dual or multiple supply sources for some materials.	(Zsidisin *et al.* 2006)	* Refer to Zsidisin *et al.* (2006)'s work about supplier risk management
RVO6	The risk of supplier acting	(Handley and	# Refer to

Item	Measurement items	Source / Reference	Description
	opportunistically on product quality is considered (e.g. using a lower grade material).	Benton 2009)	Handley and Benton (2009), item borrowed from their work related to the construct **strategic risk assessment**. The question is slightly amended to match the idea of SCQRM
RVO7	We require our supplier to follow rigorous testing rules to ensure product quality and safety.	(Tang 2008)	Newly added
RVO8	We get quality information from supplier to figure out potential quality problem in material.	(Zsidisin and Ellram 2003, Zsidisin and Smith 2005)	Newly added
RVO9	We identify potential quality and safety threats in the material we purchase.	(Zsidisin *et al.* 2006)	# Inspired from Zsidisin *et al.* (2006)'s work related to risk identification, and the question is modified to fit the context of SCQRM
RVO10	We employ a third party inspector for ensuring the quality of critical components we purchase.	(Hwang *et al.* 2006, Tang 2008)	Newly added
RVO11	We undertake robust testing to ensure the material received is not defective.	(Roth *et al.* 2008, Tang 2008)	Newly added
RVO12	We evaluate the incoming inspection report to determine if there are any potential quality problems in materials.	(Kaynak and Hartley 2008)	# Inspired from Kaynak and Hartley *et al.* (2008)'s work related to **quality data and reporting**. It has been modified and further specified to incoming inspection and SCQR identification
RVO13	Our inspection team makes a great	(Tang 2008)	Newly added

Item	Measurement items	Source / Reference	Description
	effort to ensure our received materials meet the international safety standard (e.g. RoHS and REACH).		

RISK REMEDY

Table A1.4 Measurement items of risk remedy

Item	Measurement items	Sample / Reference	Description
RRY1	We have set up a product recall/withdrawal strategy.	(Siomkos and Kurzbard 1994, Heerde *et al.* 2007)	Newly added
RRY2	We recall/withdraw the products from our customers proactively if the products are defective.	(Siomkos and Kurzbard 1994, Heerde *et al.* 2007)	Newly added
RRY3	If our product has a quality problem, we will unconditionally replace the defective products.	(Siomkos and Kurzbard 1994, Chen *et al.* 2009)	Newly added
RRY4	We have a slow response in recalling/withdrawing defective products. (reverse code)	(Siomkos and Kurzbard 1994, Heerde *et al.* 2007)	Newly added
RRY5	If our product has a quality problem, we will have an unambiguous assumption of responsibility.	(Dawar and Pillutla 2000)	Newly added
RRY6	We investigate the cause of product recall/withdrawal in order to avoid it happens again.	(Dawar and Pillutla 2000)	Newly added
RRY7	Checklists are typically provided detailing the appropriate managerial actions to follow when we need to recall/withdraw a product.	(Dawar and Pillutla 2000, Heerde *et al.* 2007)	Newly added

APPENDIX 2 – CONTENT VALIDITY TEST OF GENERATED ITEMS (PILOT TEST VERSION)

A2.1 OVERVIEW OF THE FIRST ROUND CONTENT VALIDITY TEST

The items shown in Table A2.1- Table A2.5 are the first set of items generated by the author for the SCQRM survey. They were sent to an expert panel, including industrialists (Manufacturing firm director: Dr. Andy Fok, Dr. Michael Li) and academics (Dr. Stephen Ng, Dr. Ivan Lai, and Dr. Nick Chung) for comments. The panel members were required to comment on the items based on three questions. First, are the question items understandable? Second, do the question items clearly represent the meaning of the SCQRM dimensions? Third, does the Chinese translation of the items represent the same meaning as the English version? The review process started on April 2010 and finished at the end of the May 2010.

In the beginning stage, SCQRM was conceptualised into five dimensions, instead of four. The old five SCQRM dimensions were risk shifting, risk sharing, risk prevention, risk control and risk remedy. However, most of the expert panel members commented that the boundary between risk prevention and risk control is not clear and is ambiguous. This may be due to the similar nature of two concepts – both of them are internal actions taken by the buyer firm and their major aims are to stop the unqualified materials from entering the buyer firm. The advice of the panel to reconceptualise the concept of risk prevention and control was accepted. By revising the concept and finding support from the literature, the two have been combined into one dimension, named risk avoidance. Moreover, the generated items of risk avoidance are selected from the original items from risk control and risk prevention. Thus, the number of items in risk avoidance is more than the number of

items that make up the rest of the three dimensions.[3]

Moreover, Dr. Andy Fok suggested avoiding the use of the term "risk" frequently in the questionnaire, since it may discourage the respondents from disclosing the truth or it may introduce an element of bias into the answers to the questions. Moreover, he commented that it might not feasible to ask the number of product recall happened in the informant's company, as this might hinder the response rate of questionnaire.

Most importantly, Dr. Stephen Ng mentioned that a good content validity test should not just request the panel board to review three aspects (i.e. (i) Are the question items understandable? (ii) Do the question items clearly represent the meaning of the SCQRM dimensions? (iii) Does the Chinese translation of the item represent the same meaning as the English version?) He further suggested using more robust procedures in the content validity test. The details of the revised content validity test are mentioned in the methodology chapter (Chapter 3, section 3.4.3). This includes Cohen's kappa test, followed by the inter-judge agreement test, finally, the final set of items which were translated into Chinese, and then translated back into English.

The tables below show the summaries of the comments of each measurement item in the pilot test version.

A2.3 PANEL'S COMMENTS ON THE PILOT TEST MEASUREMENT ITEMS

(i) Risk shifting (RSF)

Description: Risk shifting is the risk management practice in which the buyer firms shift the responsibility for the losses due to quality and safety problems to other

[3] The concept and the revised items of risk avoidance are further examined in the second round of content validity tests, EFA, and CFA (see chapter 5).

business parties

Critical comments from the panel:

Although the insurance company might help in reducing the negative consequence of SCQR, the insurance company is not a supply chain member, and it does not add extra value to the products.

Action taken:

We have kept the "insurance" items in the revised version of generated items, as it provides an interesting perspective in transferring SCQR. However, the items related to transferring risk to the insurance company have been dropped from the test of EFA.

Table A.1 Risk shifting pilot test items

Item	Measurement items	Comment from Expert Panel	Keep in final set of generated items?
RSF1	It is the primary responsibility of our suppliers to assure the quality of the material. 供應商 應該對 供應物料的品質保證負上主要的責任。	N/A	Revised
RSF2	The supplier should take the full responsibility for quality problems that are caused by supplier , and/or even by supplier's supplier. 供應商應該對 物料 或 子物料 (即供應商所採用的物料) 的品質物問題負上全部責任。	N/A	Revised
RSF3	For reducing the loss caused by material defects, we propose a higher penalty for the supplier. 爲了本公司從物料劣質的問題上承受較少的損失，我們會對供應商提出較高的懲罰性款項。	N/A	Revised
RSF4	If we have any loss due to defects or quality problems with the sourcing material (e.g. clients' penalty, product recall, unconditional product replacement), we penalize the	N/A	Revised

Item	Measurement items	Comment from Expert Panel	Keep in final set of generated items?
	supplier by asking for additional compensation. 若我們的產品因供應物料的劣質問題而蒙受損失 (例如，顧客的追討賠償、產品回收或無條件更換有問題產品的金錢損失)，我們會要供應商作出額外賠償。		
RSF5*	We improve supplier's material quality by setting up a high penalty for defects in supplier's contract. 我們可以用 提高罰款 的方式去改進供應商物料的品質。	Expert panel comments that it is not realistic for the firm to just increase penalty to improve component quality. They suggest it be removed or revised	Deleted; New item proposed.
RSF6*	We think that product liability insurance can cover part of the liability for losses or injuries to the consumer caused by the product defects. 我們認爲購買" 產品責任保險" (product liability insurance) 可以補償部份由產品劣質所引起賠償問題(如賠償給下游供應鍊顧客受傷)。	The word - "consumer" is not totally equal to "customer" in Chinese translation. (same in RSF7)	Deleted; New item proposed.
RSF7*	We have the product liability insurance to cover liability for losses or injuries to the consumer caused by the product's defects. 我們有購買"產品責任保險" (product liability insurance) 可以補償部份由產品劣質所引起賠償問題(如賠償給下游供應鍊顧客受傷)。	RSF6 and RSF7 are too similar to be included in a questionnaire. Panel suggests keeping RSF7 if Likert scale is used.	Keep

(ii) Risk sharing (RSR)

Description: Risk sharing involves *cooperation* with supplier jointly to reduce the quality problems from the purchasing materials.

Critical comment from panel board:

No critical comments

Table A.2 Risk sharing pilot test items

Item	Measurement items	Comment from Expert Panel	Keep in final set of generated items?
RSR1	We regularly solve quality problems jointly with our key suppliers. 我們會定期和供應商合作解決質量問題。	N/A	Keep
RSR2	We help our key suppliers to improve their product quality in the long run. 我們會長期幫助主要供應商提高產品質素。	N/A	Keep
RSR3	Hold meetings with suppliers on a regular basis to solve problems. 我們會和供應商定期舉行會議去改善質量上的問題。	There are no quality-related meaning in English items	Revised
RSR4	We invest in providing facilities for our key suppliers in order to improve product quality. 我們會投資主要供應商的設施去提高採購產品的質素。	Poor translation in Chinese	Revised
RSR5	We provide training for suppliers on quality requirements. 我們向供應商提供能達致產品品質要求的培訓。	N/A	Revised
RSR6	We help to set up tasks and procedures for suppliers (e.g.task programming) to improve supplier efficiency 我們會幫助供應商設定制作工序。	Poor translation in Chinese	Revised
RSR7	We help to monitor the quality by requiring our key suppliers to provide data relating to quality during production (e.g. error rates,	N/A	Revised

Item	Measurement items	Comment from Expert Panel	Keep in final set of generated items?
	defect rates, defects, SPC, etc.). 爲了幫助供應商 監督產品質量，我們會要求供應商提供關於生產質量的資料 (如失誤比率、缺陷比率、缺陷、统计过程控制)。		
RSR8	Key suppliers are involved early in the design stage of our new product development. 主要供應商早在設計階段時已經參與了產品開發。	N/A	Keep

(iii) Risk prevention (RPV)

Description: Risk prevention involves the activities to select the appropriate supplier, audit the supplier's facilities in order to reduce the quality uncertainties which are inherent in the supply process and in the supplier's supply network.

Critical comment from the panel:

Although the stated definition is clear, the meaning of the term "risk prevention" does not show its uniqueness, or the difference between "risk prevention" and "risk control". For example, selecting a more appropriate supplier is also a way to control risk and uncertainty. In contrast, critically inspecting the problematic material certainly is a kind of risk prevention.

Action taken:

Since the two terms are ambiguous the use of "risk prevention" and "risk control" may spoil the clarity of the dimensional concept. So, these two concepts have been integrated into one concept.

Table A.3 Risk prevention pilot test item

Item	Measurement items	Comment from Expert Panel	Keep in final set of generated items?
RPV1	We avoid using suppliers which have no ISO certificate. 我們避免選用沒有 ISO 認證的供應商。	Poor translation	In order to avoid making the survey very long this item has been deleted .
RPV2	We do not allow suppliers to use new or unproven product/process technology. 我們不容許供應商用上未經檢驗或新的生產技術。	Firm does not allow supplier to use new product/process technology?? The key is "unproven" or un-noticed by the buyer	Revised
RPV3	We rely on a small number of high quality suppliers for providing key components. 我們只會倚靠幾個優質的供應商去提供重要部件。	N/A	Keep
RPV4	Quality is our number one criterion in selecting suppliers. 品質是我們選擇供應商時最重要的條件。	N/A	Combined with RPV4 and includes risk evaluation element
RPV5	We have a thorough supplier rating system. 我們有一個全面的 供應商評分系統。	Risk evaluation should be included in supplier selection	Partially Revised
RPV6	We carry out supplier quality audits on a regular basis. 我們會對供應商 定期的質量審核 (quality audit)。	N/A	Keep
RPV7	We use dual or multiple supply sources for some materials. 我們會從 兩個或數個 供應商購買物料。	N/A	Keep
RPV8	We undertake a robust supplier evaluation process for new suppliers. 我們會用嚴謹的評估機制去評估新的供應商。	N/A	In order to prevent the survey from becoming very long this item has been deleted
RPV9	We alert our suppliers to the necessity of following international safety regulations (e.g. RoHS) when selecting materials. 我們警告供應商一定要用符合國	N/A	Partially revised

Item	Measurement items	Comment from Expert Panel	Keep in final set of generated items?
	際安全標準的物料。(如: 危害性物質限制指令 RoHS)		

(iv) Risk control (RCL)

Description: Risk control includes the inspections that stop poor quality and harmful material from being manufactured into finished products.

Critical comment from panel:

The comment is the same as that for "risk prevention".

Action taken:

The concept of risk control has been integrated with risk prevention to form a more comprehensive concept. Moreover, the pilot items of risk control are mostly related to inspection policy. They lack the sense of risk management. Thus, it is suggested that the items should be linked with risk identification which is a core concept of risk management. Therefore, some of the items have been further revised.

Table A.4 Risk control pilot test item

Item	Measurement items	Comment from Expert Panel	Keep in final set of generated items?
RCL1	Investment in inspection is undertaken in order to increase the firm's ability to discover defective incoming materials. 我們會投放資源及儀器去提高來貨檢查的水平，以提昇找出物料問題的機會。	It is suggested that the allocation of resources for identifying risk be revised	Deleted, since the concept is included with other items in the revised version
RCL2	We employ third party inspectors for ensuring the quality of purchased critical components. 爲了確保重要物料的質素，我們會聘請公正行(e.g. Intertek, BV)作出檢查，	Different from Chinese translation	Partially Revised

Item	Measurement items	Comment from Expert Panel	Keep in final set of generated items?
RCL3	We pay close attention to checking the quality of incoming materials. 我們付出很大的努力去檢查來貨的品質。	Every respondent is likely to select a high score for this question. We suggest you remove this item or ask in another way, such as "during the last 3 years, what change in effort devoted to incoming inspection has been made?"	Deleted
RCL4	We have tightened the acceptable quality level (AQL) in incoming inspections. 我們收緊了來貨物料的"允收品質水準"。	This may conflict with risk shifting	Deleted
RCL5	Incoming materials are thoroughly tested for reliability. 我們會對來貨物料進行嚴格的可靠程度(reliability) 測試。	Every respondent will most likely give a high score for this question. The panel board suggests removing this item or asking in another way.	Deleted
RCL7	We precisely record the data regarding quality and defect details in the incoming inspection. 我們會精細地紀錄下在來貨檢查的品質數據及貨物的損壞報告。	Revise to add the elements of risk identification in it.	Revised and combined with RCL8
RCL8	We monitor the rejection rates in the incoming inspection in all goods received. 我們會密切注意來貨物料的測試後的不合格的分數。	Revise to add the elements of risk identification in it.	Partially Revised
RCL9	Our inspection team pays close attention to ensuring the incoming material meets the requirements of international safety regulations (e.g. RoHS) 我們的 物料檢查團隊 付出了很大的努力去確定物料是符合國際的安全標準。(如: 危害性物	N/A	Revised

Item	Measurement items	Comment from Expert Panel	Keep in final set of generated items?
	質限制指令 RoHS)		

(v) Risk remedy (RRY)

Description: Risk remedy is the set of corrective actions taken after the delivered products have been proved to be of poor quality or even harmful to customers

Critical comment from Panel board:

Product recall only indicates the remedial action taken after the harmful product has reached the customer. Remedial action should be not be limited to destructive incidents that can harm customer health. Thus, the panel suggests that the researcher should include the issue of "withdraw" for any product with quality defects. Moreover, one of the experts mentions that the firm needs to identify the source of the harmful product, as maybe only one batch of products might have been harmed. Thus, the firm can make the correct decisions and delay of potential product recall can be avoided.

Action taken:

We have referred back to the literature, and re-conceptualised the concept of risk remedy by including the concept of product withdrawal. Interestingly, the terms for "product recall" and "product redraw" are the same in the Chinese translation. So, further descriptive details have been added in the description part in the survey. Moreover, questions related to investigation of the cause of product recall have been added to the revised measurement section of the construct.

Table A.5 Risk prevention pilot test items

Item	Measurement items	Comment from Expert Panel	Keep in final set of generated items?
RRY1	We have set up a product recall/withdrawal strategy 我們經以設定了產品回收的策略。	N/A	Revised
RRY2	We recall/withdraw the products from our customers if the products are defective 當發現產品有問題時，我們會回收有問題的產品。	N/A	Revised
RRY3	We recall/withdraw the defective products proactively 當發現產品有問題，我們會積極主動地回收有問題的產品。	Very similar meaning to RRY2	Deleted, combined with RRY2
RRY4	We have a slow response in recalling/withdrawing defective products. (reverse code)在回收有問題的產品時，我們反應是緩慢的。	N/A	Revised Reverse coded in final version
RRY5	If our products have quality problems, we will unambiguously assume responsibility for this. 當發現產品有問題，我們會清楚明確地承認有關的責任。	Poor translation	Revised
RRY6	If our products have quality problems, we will unconditionally replace the defective products 如本公司查明產品品質有問題時，我們會無條件地更換相關產品。	N/A	Revised
RRY7	Checklists are typically provided detailing the appropriate managerial actions to be taken in response to any product harm crisis that occurs. 我們已準備了 關於應對產品品質及安全危機發生的核對用的清單。	N/A	Revised

APPENDIX 3 –CONTENT VALIDITY TEST OF GENERATED ITEMS (SECOND ROUND)

Validity Assessment
Supply Chain Quality Risk Management Dimension

1. Description

Supply chain risk management practices are defined as the set of activities undertaken by an organization to promote effective risk management in its *global sourcing*. These practices are risk management strategies that are especially aim to manage contingency and catastrophic product harm incidents, which may not include in the focus of generic supply chain risk management framework. The SCRM practices are proposed to be a multi-dimensional concept, including downstream and upstream supply chain. In reviewing and consolidating the literatures (CCRRCA 2009, Camuffo *et al.* 2007, McKinsey&Company 2009, Braunscheidel and Suresh 2009, Heerde *et al.* 2007), Five distinctive dimensions are:

Dimension 1 - Risk shifting (RSF) is the risk management practice that the buyer firms **shift** the responsibility of the losses due to quality and safety problems to other parties, such as suppliers and insurance co (product liability insurance).
Dimension 2 - Risk sharing (RSR) involves the **cooperation** with supplier jointly to reduce the quality problems from the purchasing materials. It also forms a *cushioning effect* to the destructive incidents by absorbing the negative impact by buyer-seller cooperation.
Dimension 3 - Risk avoidance (RAV) involves the activities to **select the appropriate supplier**, audit the supplier facility in order to lower down the quality uncertainties. Also, it includes the **inspective and identification actions of quality risk** that stop the poor quality and harmful material being manufactured to finished products.
Dimension 4 - Risk remedy (RRY) is the set of **corrective actions** taken after the delivered products being revealed and proven that they are in poor quality or even harmful to customers
Below are the item measurement generated from reviewing literatures and gathering the practitioners' suggestions. The measurement items listed below are aimed to measure the degree of agreement of adopting supply chain quality risk management practices.

**Note: PLEASE let the researcher (Mike) knows if you have finished task 1. The correct answer of task 1 will be given before task 2 begins*

2. Please rate the statements to the most relevant dimension* and then mark the adequacy to the specific dimension. <u>One statement only belongs to one dimension.</u>

	TASK 1	**TASK 2**						
Statement	**Belong to Which dimension?**	**Adequacy?(1=barely adequate;7=almost perfect) Put "x" in the selected adequacy level**						
	1 / 2 / 3 / 4	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1. We require our key suppliers to return the documents or statistical process control (SPC) data so we can keep track of the production quality.								

	TASK 1	TASK 2						
Statement	**Belong to Which dimension?**	**Adequacy?(1=barely adequate;7=almost perfect) Put "x" in the selected adequacy level**						
2. For reducing the loss caused by material defects, we propose a higher penalty for the supplier.								
3. We setup tasks and procedures for supplier production with our key suppliers.								
4. We use dual or multiple supply sources for some materials.								
5. We evaluate the incoming inspection report to determine if there are any potential quality problems in materials.								
6. We have set up a product recall/withdrawal strategy.								
7. We undertake robust testing to ensure the material received is not defective.								
8. We get quality information from supplier to figure out potential quality problem in material.								
9. We include key suppliers in the design stage of new products.								
10. We regularly solve problems jointly with our key suppliers.								
11. We have product liability insurance to cover liability for losses or injuries to the consumer that are caused by product defects.								
12. Managing the quality of the material is primarily the responsibility of suppliers.								
13. If our product has a high potential risk in quality and safety, we would purchase product liability insurance.								
14. Product quality and safety are the crucial requirements in our supplier selection process.								
15. If our product has a quality problem, we will have an unambiguous assumption of responsibility.								
16. We investigate the cause of product recall/withdrawal in order to avoid it happens again.								
17. We identify potential quality and safety threats in the material we purchase.								
18. We hold meetings with suppliers on a regular basis to solve quality problems.								
19. We think that the supplier should take most of the responsibility for quality problems that are caused by the supplier, and/or even from the supplier's suppliers.								
20. We rely on a small number of high quality suppliers for providing key components.								
21. We prevent suppliers from using unproven product/process technology.								
22. If we have any loss due to defects or have any quality problems with the sourced materials (e.g. clients' penalty, product recall, unconditional replacement), we penalize the								

	TASK 1	TASK 2						
Statement	**Belong to Which dimension?**	**Adequacy?(1=barely adequate;7=almost perfect) Put "x" in the selected adequacy level**						
supplier additionally by asking for compensation.								
23. We help our key suppliers to improve their product quality in the long run.								
24. We have laid down a detailed description of suppliers' responsibilities which will be applied if defects are found in the purchased materials.								
25. We have a fast response in recalling/withdrawing defective products.								
26. Checklists are typically provided detailing the appropriate managerial actions to follow when we need to recall/withdraw a product.								
27. Our inspection team makes a great effort to ensure our received materials meet the international safety standard (e.g. RoHS and REACH).								
28. The risk of supplier acting opportunistically on product quality is considered (e.g. using a lower grade material).								
29. We provide training for suppliers on quality requirements.								
30. We employ a third party inspector for ensuring the quality of critical components we purchase.								
31. If our product has a quality problem, we will unconditionally replace the defective products.								
32. We invest in our key supplier's facility to improve product quality.								
33. We require our supplier to follow rigorous testing rules to ensure product quality and safety.								
34. We carry out quality audit on suppliers on a regular basis.								
35. We recall/withdraw the products from our customers proactively if the products are defective.								

APPENDIX 4 – QUESTIONNAIRE (ENGLISH VERSION)

Survey: An investigation into quality risk in global sourcing

Nottingham University
Business School

Survey Objective

The information from this survey will be useful to researchers in studying the solutions in reducing quality risks in global sourcing. It also aims to clarify the understanding about the relationship between supply chain management practices and potential supply chain risks. As with the answers to questions in subsequent sections of the survey, the information that you provide will not be used to identify individual companies. Please feel comfortable to give responses; in most cases, our research has shown that it is important to have approximate answers rather than none to all.

Name:_____
Email:_____
Company:_____
Phone:_____

1.1. Which category does your firm belong to (please choose one)?

Industry description	**Please select one**
Apparel and other finished products made from fabrics and similar materials	
Furniture and fixtures	
Rubber and miscellaneous plastics products	
Fabricated metal products, except machinery and transportation equipment	
Industrial and commercial machinery and computer equipment	
Electronic and other electrical equipment and components, except computer equipment	
Measuring, analyzing, and controlling instruments; photographic, medical and optical goods	
Miscellaneous manufacturing industries	

1.2. What is your position in your firm?

Director/ CEO/GM	☐	Purchasing Manager	☐
Supply Chain Manager	☐	Project Manager	☐
Quality Manager	☐	Others: _____	

1.3. Approximately, What is the annual sales of your firm?

Less than HK$10 million	Between HK$10 million and HK$50 million	Between HK$50 million and HK$200 million	More than HK$200 million

1.4. Approximately, how many full-time employees work for your company?
____Employees

Please indicate your level of agreement to the following statement by a circle: In my firm: (1= strongly disagree; 7=strongly agree)								
RSF1	We think that the supplier should take most of the responsibility for quality problems that are caused by the supplier, and/or even from the supplier's suppliers.	1	2	3	4	5	6	7
RSF2	Managing the quality of the material is primarily the responsibility of suppliers.	1	2	3	4	5	6	7
RSF3	For reducing the loss caused by material defects, we propose a higher penalty for the supplier.	1	2	3	4	5	6	7
RSF4	If we have any loss due to defects or have any quality problems with the sourced materials (e.g. clients' penalty, product recall, unconditional replacement), we penalize the supplier additionally by asking for compensation.	1	2	3	4	5	6	7
RSF5	We have laid down a detailed description of suppliers' responsibilities which will be applied if defects are found in the purchased materials.	1	2	3	4	5	6	7
RSF6	If our product has a high potential risk in quality and safety, we would purchase product liability insurance.	1	2	3	4	5	6	7
RSF7	We have product liability insurance to cover liability for losses or injuries to the consumer that are caused by product defects.	1	2	3	4	5	6	7
RSR1	We regularly solve problems jointly with our key suppliers	1	2	3	4	5	6	7
RSR2	We help our key suppliers to improve their product quality in the long run.	1	2	3	4	5	6	7
RSR3	We hold meetings with suppliers on a regular basis to solve quality problems.	1	2	3	4	5	6	7
RSR4	We invest in our key supplier's facility to improve product quality.	1	2	3	4	5	6	7
RSR5	We provide training for suppliers on quality requirements.	1	2	3	4	5	6	7
RSR6	We set up tasks and procedures for supplier production with our key suppliers.	1	2	3	4	5	6	7
RSR7	We require our key suppliers to return the documents or statistical process control (SPC) data so we can keep track of the production quality.	1	2	3	4	5	6	7
RSR8	We include key suppliers in the design stage of new products.	1	2	3	4	5	6	7

RVO1	We prevent suppliers from using unproven product/process technology.	1	2	3	4	5	6	7
RVO2	We rely on a small number of high quality suppliers for providing key components.	1	2	3	4	5	6	7
RVO3	Product quality and safety are the crucial requirements in our supplier selection process.	1	2	3	4	5	6	7
RVO4	We carry out quality audit on suppliers on a regular basis.	1	2	3	4	5	6	7
RVO5	We use dual or multiple supply sources for some materials.	1	2	3	4	5	6	7
RVO6	The risk of suppliers acting opportunistically on product quality is considered (e.g. using a lower grade material).	1	2	3	4	5	6	7
RVO7	We require our suppliers to follow rigorous testing rules to ensure product quality and safety.	1	2	3	4	5	6	7
RVO9	We identify potential quality and safety threats in the material we purchase.	1	2	3	4	5	6	7
RVO10	We employ a third party inspector for ensuring the quality of critical components we purchase.	1	2	3	4	5	6	7
RVO11	We undertake robust testing to ensure the material received is not defective.	1	2	3	4	5	6	7
RVO12	We evaluate the incoming inspection report to determine if there are any potential quality problems in materials.	1	2	3	4	5	6	7
RVO13	Our inspection team makes a great effort to ensure our received materials meet the international safety standard (e.g. RoHS and REACH).	1	2	3	4	5	6	7
RRY1	We have set up a product recall/withdrawal strategy.	1	2	3	4	5	6	7
RRY2	We recall/withdraw the products from our customers proactively if the products are defective.	1	2	3	4	5	6	7
RRY3	If our product has a quality problem, we will unconditionally replace the defective products.	1	2	3	4	5	6	7
RRY4	We have a slow response in recalling/withdrawing defective products (reverse code).	1	2	3	4	5	6	7
RRY5	If our product has a quality problem, we will have an unambiguous assumption of responsibility.	1	2	3	4	5	6	7
RRY6	We investigate the cause of product recall/withdrawal in order to avoid it happens again.	1	2	3	4	5	6	7
RRY7	Checklists are typically provided detailing the appropriate managerial actions to follow when we need to recall/withdraw a product.	1	2	3	4	5	6	7

Over the past 3 years, please indicate the level of changes in your firm (1= decreased significantly; 4= no change; 7= increase significantly)								
QP1	Over the last three years, our capability of offering a reliable product that meets customer needs.	1	2	3	4	5	6	7
QP2	Over last three years, our capacity of offering safe-to-use product that meets customer needs	1	2	3	4	5	6	7
QP3	Over the last three years, our capability of offering durable product that meets customer needs.	1	2	3	4	5	6	7
QP4	Over the last three years, our capability of offering quality product that meets customer expectations.	1	2	3	4	5	6	7
QP5	Over the last three years, our capability of offering high performance product that meets customer needs.	1	2	3	4	5	6	7
Please indicate your level of agreement to the following statement by a circle: In my firm: (1= strongly disagree; 7=strongly agree)								
QP6	Over the last three years, there has been a steady decline in the number of customer complaints.	1	2	3	4	5	6	7
QP7	Over the last three years, there has been steady decline in the number of product litigation claims.	1	2	3	4	5	6	7
QP8	Over the last three years, there has been a steady decline in the number of warranty claims	1	2	3	4	5	6	7
Over the past 3 years, please indicate the level of changes in your firm : (1= decreased significantly; 4= no change; 7= increase significantly)								
FP1	Return on investment	1	2	3	4	5	6	7
FP2	Market share	1	2	3	4	5	6	7
FP3	Customer loyalty	1	2	3	4	5	6	7
FP4	The number of successful new product introductions.	1	2	3	4	5	6	7
FP5	Long-term profit	1	2	3	4	5	6	7

APPENDIX 4 – QUESTIONNAIRE (CHINESE VERSION)

全球化物料採購的品質管理研究

Survey Objectives

在全球性物料採購過程中，對供應商的品質管理往往變得困難，這種品質危機的源頭來自上游供應鍊，而業界到學術界都未有對這種採購的品質管理問題的解決方法進行深入的研究。此問卷調查的主要目的是了解如何用不同的供應鍊的管理手法去減少購買劣品物料的機會，您所提供的資料只會用作我們的研究。如果發現對本問卷問題未能完全肯定的回答，請嘗試選出**最接近**的答案，謝謝。

姓名:_____

Email:_____

公司名稱:_____

1. 1 貴公司是屬於以下那一個行業？

衣服及紡織 ☐	金屬鑄造 ☐	測量儀器 ☐
傢俱及配件 ☐	工業及商業機械 及電腦產品 ☐	
塑膠產品 ☐	電子產品及配件 ☐	其他工業 ☐

1.2. 您在公司在是什麼職位?

Director/ CEO/GM ☐	Purchasing Manager ☐
Supply Chain Manager ☐	Project Manager ☐
Quality Manager ☐	Others: _____ ☐

1.3.貴公司大概有多少全職員工 (連工廠員工及管理人員)？ _____ 人

1.4. 我們的年销售額 (Annual sales):

<HK$10 million 一千萬	HK$10 to 50 million 一千至五千萬	HK$50 to 200 million 五千萬 至 二億	>HK$200 million 多過二億

請圈出您對以下句子的同意程度: 1=非常不認同; 7=非常認同

	非常不認同						非常認同
RSF1 我們認爲供應商 應該對 供應物料的品質物問題負上主要的責任，即使的問題源頭是來自於更上游的供應商	1	2	3	4	5	6	7
RSF2 供應商應該負上品質物料的保證的主要責任	1	2	3	4	5	6	7
RSF3 在處理物料劣質的問題時，我們會對供應商提出高的懲罰性款項	1	2	3	4	5	6	7
RSF4 若我們的產品因供應物料的劣質問題而蒙受損失 (例如，顧客的追討賠償、產品回收或無條件更換有問題產品的金錢損失)，我們會要供應商作出額外賠償	1	2	3	4	5	6	7

RSF5 我們在其同的文件上有清楚列明供應商對劣質產品上要負的責任	1	2	3	4	5	6	7
RSF6 若果我們的產品有頗高的品質風險時，我們會購買"產品責任保險"	1	2	3	4	5	6	7
RSF7 我們 有 購買 "產品責任保險" (product liability insurance)以補償部份由產品劣質所引起的損失(如賠償給下游供應鍊顧客受傷)	1	2	3	4	5	6	7
RSR1 我們會定期和供應商 合作解決 質量問題	1	2	3	4	5	6	7
RSR2 我們會 長期幫助 主要供應商提高產品質素	1	2	3	4	5	6	7
RSR3 我們會和供應商 定期舉行會議 去改善質量上的問題	1	2	3	4	5	6	7
RSR4 我們會向主要供應商 投資設備 去提高他們的產品質素	1	2	3	4	5	6	7
RSR5 我們向供應商提供能達致產品品質要求的培訓	1	2	3	4	5	6	7
RSR6 我們會和 供應商 共同設定制造產品的工序	1	2	3	4	5	6	7
RSR7 爲了幫助供應商 監督產品質量，我們會要求供應商提供關於生產質量的資料 (如失誤比率、缺陷比率、缺陷、統計過程控制)(e.g. error rate, defect rate, defect, SPC)	1	2	3	4	5	6	7
RSR8 主要供應商早在 設計階段 時已經參與了產品開發	1	2	3	4	5	6	7
RVO1 我們不容許供應商在 未通知我們的情況下 用上未經檢驗 或 新的生產技術	1	2	3	4	5	6	7
RVO2 我們只會倚靠幾個 優質的供應商去提供重要部件	1	2	3	4	5	6	7
RVO3 品質及安全是我們選擇供應商時 最重要的條件	1	2	3	4	5	6	7
RVO4我們會對供應商 定期的質量審核 (quality audit)	1	2	3	4	5	6	7
RVO5 我們會從 兩個或數個 供應商購買物料	1	2	3	4	5	6	7
RVO6 我們會用評估 供應商在品質上取巧及不誠實的危機 (如用較差的物料)	1	2	3	4	5	6	7
RVO7 我們要求供應商一定要用進行嚴謹的測試以確保品質安全	1	2	3	4	5	6	7
RVO9我們會尋找及確認 在物料裡的 潛在品質危機							
RVO10 爲了確保重要物料的質素，我們會聘請公正行作出檢查	1	2	3	4	5	6	7
RVO11 我們會嚴謹去檢查來貨的品質以確保劣品不會流入工場	1	2	3	4	5	6	7
RVO12我們會精細檢查來貨檢查的品質數據以找出潛在的品質問題	1	2	3	4	5	6	7
RVO13 我們的 物料檢查團隊 付出了很大的努力去確定物料是符合國際的安全標準。(如: 危害性物質限制指令 RoHS 或 REACH 法規)	1	2	3	4	5	6	7
RRY1 我們已經設定了 產品回收的策略	1	2	3	4	5	6	7
RRY2當發現產品有問題，我們會積極主動地回收有問題的產品	1	2	3	4	5	6	7
RRY3如本公司查明產品品質有問題時，我們會無條件地更換相關產品	1	2	3	4	5	6	7
RRY4 在回收有問題的產品時，我們反應是**緩慢**的 ®	1	2	3	4	5	6	7
RRY5 當發現產品有問題，我們會清楚明確地 公司需要	1	2	3	4	5	6	7

承擔的責任							
RRY6 我們會去查考品質回收的問題來源以確保同樣的問題不會再發生	1	2	3	4	5	6	7
RRY7 我們已準備了 關於應對產品品質及安全危機發生的核對用的清單	1	2	3	4	5	6	7

在過去 3 年，貴公司在以下各種產品品質層面的能力上有什麼轉變？1=顯著減少; 4=不變; 7=顯著提昇

Quality Performance	顯著減少			不變			顯著提昇
QP1在過去3年，我們的產品 達到顧客要求的 品質可靠方面的能力	1	2	3	4	5	6	7
QP2在過去3年，我們的產品 達到顧客要求的 產品安全方面的能力	1	2	3	4	5	6	7
QP3在過去3年，我們的產品 達到顧客要求的 產品耐用方面的能力	1	2	3	4	5	6	7
QP4在過去3年，我們的產品 達到顧客期望的 產品品質方面的能力	1	2	3	4	5	6	7
QP5在過去3年，我們的產品 達到顧客要求的 產品工能方面的能力							
請圈出您對以下句子的同意程度:	非常不認同						非常認同
QP5 和三年前比較，顧客在品質上的投訴穩定持續地減少	1	2	3	4	5	6	7
QP7 和三年前比較，我們因爲 產品不合格而需要的賠償/索償的金額 有穩定持續地減少 (Product litigation claims)	1	2	3	4	5	6	7
QP8 和三年前比較，我們需要在 “保養產品” 的成本穩定持續地減少(Warranty claims)	1	2	3	4	5	6	7

在過去 3 年，貴公司在以下各種層面的成果上有什麼轉變？1=顯著減少; 4=不變; 7=顯著提昇

Firm Performance	顯著減少			不變			顯著提昇
FP1 投資回報率	1	2	3	4	5	6	7
FP2 市場佔有率	1	2	3	4	5	6	7
FP3顧客忠誠度	1	2	3	4	5	6	7
FP4成功推出市面的新產品	1	2	3	4	5	6	7
FP5長遠收益	1	2	3	4	5	6	7